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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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SIR JAMES CURRIE, K.C.M.G., K.B.E.

As we go to the press we learn with deep regret of the death on Tuesday, March 16th, in Cambridge, of Sir James Currie, K.C.M.G., K.B.E., Chairman of the Governing Body of the Imperial College of Tropical Agriculture, and Director of the Empire Cotton Growing Corporation. An obituary notice will appear in our next issue.

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THE WEST INDIAN FRUIT AND VEGETABLE COUNCIL.

Eastern Group.

WE have already referred to the origin, objects and work of the Eastern Group of the West Indian Fruit and Vegetable Council which first met in St. Lucia in 1935. The results of this meeting were summarised in these columns* and it is now proposed to record briefly what occurred at the second meeting of the Council which has just been held in Trinidad, at the Imperial College of Tropical Agriculture. This was opened by Sir Geoffrey Evans and attended by both official and unofficial representatives from Trinidad, British Guiana, St. Lucia, Bermuda, Antigua, Dominica, Grenada and Montserrat. The chair was taken by the Commissioner of Agriculture who is President of the Council. A comprehensive agenda was considered. In the first instance a summary of the action taken on the recommendations of the Council made at its first meeting was reviewed and further action recommended where necessary.

The chief business of the meeting was concerned with the marketing of various crops produced in the Eastern West Indies, and perhaps the most important conclusion to be drawn from the general trend of the discussions was the recognition of the need for co-operation between exporters in the marketing of their produce. Not only is co-operation between the members of the Eastern Group considered desirable or even necessary for successful marketing, but also co-operation between the Eastern Group and the Western Group of Colonies. Thus, one of the main recommendations of the meeting was that the Governments of Jamaica, British Honduras and the Bahamas, should be invited to organise the Western Group Council as soon as possible, and that when organised the Western Group Council should investigate the methods of marketing produce exported from those Colonies, especially in Canada where produce from the Eastern Group is liable to enter into competition with that exported from the Western Group. Further, in the matter of co-operation, it was felt that there is urgent need for the formation of Island co-operative associations for the marketing of minor products by the smaller Islands as a stepping stone to a greater measure of inter-Island co-operation. It was suggested that such

* *Tropical Agriculture*, Vol. XII, No. 6, 1935.

co-operation could be fostered in the early stages by the affiliation of local associations to this Council or similar parent body.

Much attention was paid to the lime industry and the marketing of distilled lime oil and green limes. In this connection a Director of the West Indian Lime Oil Sales Company Limited, gave an account of the formation and activities of the Company, and pointed out the advantages to be derived from co-operation between all lime oil exporters in the Eastern Group. He appealed to exporters who have not yet joined the West Indian Lime Oil Sales Company to join the co-operative organisation for the purpose of promoting both their own interests and those of the Company. The Council recommended that producers and shippers in the Eastern Group other than in the Islands of Trinidad, Tobago and St. Lucia where co-operative organisations are already in existence, should reconsider the possibility of forming co-operative marketing organisations and joining the West Indian Lime Oil Sales Company Limited.

In regard to green limes discussion was focussed on the relative merits of marketing on an *f.o.b.* basis or on consignment. The Council decided that shippers of green limes in each island shou d consider the possibility of making arrangements to ship through a single organisation or through one of their numbers such quantities as are sold on the *f.o.b.* basis, or, if on a consignment basis, only such quantities as are advised by their broker. The need for advertising green limes was also recognised and the Council urged the early consideration of schemes for this purpose. It was suggested that funds for undertaking an advertising campaign should be raised by imposing a cess on all lime products in British Guiana and the British West Indies, or, in the case of those Governments which already imposed export taxes on lime products, by special grants.

The position of the grapefruit and orange industries was reviewed by the Council. The Secretary-Manager of the Co-operative Citrus Growers' Association of Trinidad and Tobago, gave an account of the working of his organisation with special reference to the canning operations conducted by the Association. Consideration of the reports on the methods of marketing Jamaica grapefruit and oranges, particularly in Canada, led to the recommendation by the Council that representations be made to the Government of Jamaica in regard to the system of marketing grapefruit and oranges in that Colony, with the object of regulating shipments and preventing unnecessary and harmful competitive selling. The opportunity was also taken of communicating to members of the Council information on various subjects relating to the citrus industry and papers were read on " Citrus scab disease on grapefruit in Trinidad," " The seedlessness in Marsh grapefruit and related problems " and on " The Citrus Weevil ".

The question of the establishment of a better marketing organisation also found a prominent place during the discussion on the tomato industry. Reports from the Trade Commissioner in Canada indicated that there was great need for organising the marketing of tomatoes produced in the Bahamas, and in this respect the Council recommended that the necessary representations be made to the Government of the Bahamas.

Although of relatively minor importance consideration of the smaller fruit industries, such as mangoes and avocado pears, and of miscellaneous vegetables other than tomatoes, was not neglected. It was felt that renewed efforts should be made to increase the sale of mangoes in the United Kingdom market, and it was suggested that in this respect the co-operation of exporters in Jamaica should be invited. In connection with this subject the Officer-in-Charge of the Low Temperature Research Station at the Imperial College of Tropical Agriculture gave an account of the work of the Station with special reference to the storage of grapefruit, mangoes and avocado pears.

The unfavourable consequences of the recent Canada-United States Trade Agreement on the fruit and vegetable trade of the Eastern Group, and in particular, on the vegetable trade of Bermuda, were stressed, and it was urged that the Secretary of State for the Colonies be asked to draw the attention of the Canadian Government to the serious effects of this Trade Agreement on the fruit and vegetable trade between the West Indian area and Canada.

A careful survey was made of the position of the banana industry in Trinidad, the Windward Islands and Dominica and there was general agreement that unless better prices could be obtained, a standard of cultivation necessary for the production of fruit of the desired quality could not be reached. It was consequently decided to recommend that negotiations be opened with the Canadian Banana Company with a view to the arrangement of a system of payment for fruit on a more remunerative basis.

The position of the coconut and copra industry was also reviewed and an interesting address was given by the Chairman of the Coconut Growers' Association Limited in the Colony of Trinidad and Tobago, on the position of the industry in Trinidad and on the circumstances which led to the formation of the Coconut Growers' Association. He indicated the objects for which the Association was formed and gave an account of its activities and achievements since its formation. He also put forward certain proposals which involved the co-operation of exporters in the other Islands of the Eastern Group with his Association and were designed to effect the stabilization of the price of coconuts and copra at a remunerative level both in Trinidad and in the other exporting Islands.

Delegates from Dominica, St. Lucia and Grenada displayed much interest in these proposals and arrangements were made for further discussion between them and representatives of the local Association.

Reference was made to the work the Trade Commissioner in Canada for the Eastern Group of the British West Indies had accomplished in the rôle of Marketing Intelligence Officer. The Council expressed appreciation of the services rendered, but was in general agreement that the Trade Commissioner would be in a position to extend the scope of his services in this connection if he were granted funds for increased travelling. The President was therefore requested to invite the Governments of those Colonies concerned to increase their contributions to the Office of the Trade Commissioner in order that this useful work might be undertaken.

In conclusion, the President thanked the delegates for their co-operation in the work of the Council, and reminded them of the two ideals of co-ordination and co-operation to the furtherance of which the Council was pledged. He was more than ever convinced that means must be found for co-ordinating the production and marketing of fruit and vegetables in the Eastern Group. In this way and in this way only could the adverse effect of competitive selling be eliminated. "By co-operation amongst the Colonies themselves as well as the co-operation of particular interests in each Colony valuable advances can be made in that united effort and uniform policy necessary to enable the British West Indian colonies as a whole to develop their agricultural resources." The Council must continue working with these objects in view and he considered that the work accomplished at this meeting would result in a definite step forward in this direction.

FURTHER OBSERVATIONS ON THE STORAGE OF TRINIDAD CITRUS FRUITS.

Storage experiments during 1934-35 (1) together with earlier, preliminary investigations (3), (5) showed that, in certain respects, citrus fruits in Trinidad differ in their storage requirements from those grown elsewhere. Thus the storage temperature required for Trinidad grapefruit and for two varieties of oranges was found to be 45°F., whereas lower temperatures are usually advocated elsewhere. Again, the fungi producing the greater proportion of the wastage are not those most commonly responsible in other citrus producing countries.

The results of a second season's experiments are incorporated in two further Memoirs of the Low Temperature Research Station (2), (4). It has been found that the total quailing period between picking and packing required by Trinidad grapefruit from January onwards, *i.e.*, normally the beginning of the dry season, can be reduced to an absolute minimum without the production of skin blemishes. This is subject to the *proviso* that fruit is not picked immediately after rain or whilst dew is still on the fruit.

Considerable attention has been paid to the effect of packing shed handling and of different antiseptic treatments on citrus fruits. In general it has been found that the less handling the fruit receives the lower the rate of loss in weight during storage and the less the blemishing developed. Since both these phenomena are important in relation to subsequent fungal wastage, handling should be reduced to a minimum. The use of a boric acid, borax or borax-boric acid dip has been found to be definitely detrimental to Trinidad grapefruit. During a relatively short storage and distribution period, 20 days at 45°F. followed by 14 days at 60°F., fruit which had received the standard borax-boric acid dip (six parts borax : one part boric acid, eight per cent. at 100°F. for five seconds) at the local packing shed showed 33 per cent. wastage against 5 per cent. in untreated fruit. During the storage period the borax treatment had increased the *fungal* wastage four times whilst *blemishing* was increased about 20 times; these blemishes were followed by rotting, chiefly by *Colletotrichum gloeosporioides*. As a result of these investigations the use of borax has been discontinued in Trinidad.

A brief account is given of the use of borax in other countries and suggestions are offered to account for the difference between Trinidad results and those reported by other workers.

The caustic wash given to clean the fruit and loosen scale insects, appears to have no appreciable effect on the keeping quality of grapefruit. Numerous alternative disinfectant washes have been employed in other countries with variable success but these have not been tested at the Low Temperature Research Station. The waxing process which follows the caustic wash is definitely advantageous in that it results in a decrease of loss in weight during storage and in an enhanced appearance.

A comprehensive scheme of experiments on the use of iodised wraps has shown that these are of doubtful merit under normal commercial conditions. This is due to the critical relationship between the development of the fungi responsible for rotting and the effect of the volatilized iodine on the fungus and on the fruit tissues. Iodized wraps may (*a*) control fungal wastage, (*b*) show no appreciable effect or (*c*) actually increase wastage in grapefruit and oranges according to the time elapsing between picking and the application of wraps. The use of ammonium bicarbonate as a source of ammonia to control fungal wastage of citrus fruits has likewise been found undesirable.

In general the rational use of antiseptic treatments has been shown to involve an appreciation of the relationship between the nature of the

specific storage fungi involved, the course of their pathogenicity and the effect of the treatment on the fruit.

Modifications to the conditions in the storage rooms were attempted in order to reduce the rate of loss in weight and blemishing, but the cold storage equipment was not sufficiently flexible to achieve any marked improvement. This situation is now being remedied by considerable alterations.

The conditions causing the production of chill blemishes have received further attention. At temperatures of 45°F. or lower, increased rates of air movement, or decreased humidities resulted in the earlier appearance of chill spots. Various wraps, on the other hand, delayed their appearance. A temperature of 42°F. did not produce chilling appreciably earlier than 45°F. but it is evident that this latter temperature is too low for the prolonged storage of Trinidad grapefruit.

Various types of skin blemishes encountered during these storage experiments are described. They consist of oleocellosis (" goose-flesh " blemishing), desiccation at previously bruised areas occurring during prolonged storage, borax injury and blemishes due to accumulated gases. The relation between these blemishes of physiological origin and fungal wastage is discussed.

In order to avoid unfavourable marketing periods the picking of ripe grapefruit has been delayed for periods of one month and longer. Whilst no storage trials have been possible with such fruit, preliminary studies of their physiological condition indicate that only slight alterations take place during this extended period on the tree.

Grapefruit from different localities in Trinidad have again shown considerable differences in their susceptibility to wastage under the same storage conditions. Before uniform keeping quality can be attained, considerable attention will be necessary by those growers of fruit of poorer keeping quality. This is in conjunction with the fact that the most prevalent storage rots of Trinidad grapefruit are those whose incidence has been shown to be related to orchard conditions.

Preliminary investigations have been made on some of the more fundamental physiological problems. Respiration experiments showed that grapefruit normally possesses a low internal concentration of carbon dioxide, that accumulation of this gas in the atmosphere surrounding the fruit is accompanied by increased internal concentrations and that increased fungal wastage may be incurred as a result of exposure to relatively low carbon dioxide concentrations. These observations are of importance in relation to the storage of citrus fruits without adequate ventilation. The titratable acidity of the juice of grapefruit was found to decrease slightly during prolonged cold storage. As a criterion of quality, however, it is inadequate, a marked loss in flavour occurring in fruit still possessing high acidity.

An appendix dealing with purely mycological aspects of citrus storage is given in one of the Memoirs (4).

In considering the wastage records given in these Memoirs it must be remembered that the wastage to be expected during a short distribution period at higher temperatures will be reduced not in direct proportion to the length of the distribution period after cold storage but to a considerably lower value. This is a consequence of the rapid increase in wastage which occurs after about three weeks at the " distribution " temperature used (60°F.).

Emphasis is laid upon the importance of maintaining a high relative humidity in storage rooms in order to reduce the loss in weight of citrus fruits. Since the chief source of fungal wastage in Trinidad grown citrus fruit is that due to stem-end rots and since antiseptic washes have proved detrimental it will be seen that early cold storage with rapid cooling is extremely desirable in order to check fungal development and reduce loss in turgor. At higher storage temperatures there is a greater liability to increased loss of moisture: consideration of the maximum humidity possible without incurring the spread of surface moulds is therefore necessary. The opinion has been expressed in the United States that the relative humidity in the storage of oranges, grapefruit and lemons should be close to 90 per cent.

It cannot be too strongly emphasised that the above conclusions and recommendations apply only to Trinidad-grown grapefruit and will undoubtedly require modification if applied to other areas. This has repeatedly been brought to the writers' attention even in respect of fruit grown in neighbouring islands where different growth conditions prevail. Nevertheless the general conclusions reached undoubtedly have wide application in the problems of reduction of blemishing and fungal wastage of citrus fruits produced in different countries.

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RECENT INVESTIGATIONS ON SUGAR-CANE AND SUGAR-CANE SOILS IN ST. KITTS.

III.—CULTURAL, MULCHING AND MANURIAL EXPERIMENTS REAPED IN 1936.

By P. E. Turner and R. E. Kelsick.

Introduction.

A Scheme of field experiments on sugar-cane was inaugurated in St. Kitts in 1933 under the auspices of the Sugar-Cane Investigation Committee of the island. The scheme is a consequence of a critical review of agricultural practices in use in St. Kitts (1).

The first series of experiments laid down under the scheme was harvested in 1935. The information to which it gave rise has been summarised in earlier issues of this *Journal* (2).

A second series of experiments has been reaped in 1936. The results of the experiments with varieties, time of planting and distance of spacing included in this series have already been discussed (3). The results of the cultural, mulching and manurial experiments are recorded in this paper.

Cultural Experiments.

Depth of Preparatory Cultivation.

Information with regard to effect of depth of preparatory cultivation on yield of plant canes is now available from two exploratory experiments. One of the experiments enables a comparison of the merits of 'close' ploughing to depths of six inches and one foot in a dry area of the lower lands. The other provides a measure of the effect of opening the subsoil below the furrows by means of a chisel (knife) to a depth of six inches in a wet area of the upper lands.

The method of preparatory cultivation in standard use has been earlier described (2).

Depth of close ploughing in a dry area.

This experiment was laid down on a deep soil containing 57 per cent. coarse sand, 13 per cent. fine sand, 14 per cent. silt and 10 per cent. clay. The layout was in the form of eight randomised blocks with two replicates of each treatment in each block. The ploughing operations were carried out with cattle. All plots on the experimental area were first 'close' ploughed to a depth of six inches. The appropriate plots were ploughed again to a further six inches, making one foot in all. Furrows were then prepared, and cross-holed in the customary manner.

The yield data for the plant canes are set out in Table I.

Table I.—Depth of 'close' ploughing with cattle in relation to yield of plant canes on a deep sandy soil of the lower lands.

Area: Dry. *Estate*: Douglas.
Ploughed: Nov. 1934. *Variety*: S.C. 12/4.
Planted: 25/11/34. *Reaped*: 12/2/36.
Rainfall (14¾ months): 55 inches.
Layout: Randomised blocks.

Depth of close ploughing.	Yield of plant canes * (tons per acre).
6 inches	22.93
12 inches	22.75

* Mean yields for 16 replicates.

In this experiment there is nothing to choose between the yields of the first crop harvested on the two series of plots. *Under the existing conditions ploughing to a depth greater than six inches may therefore be unnecessary on the deep sandy soils of the lower lands.*

Difficulty was experienced in ploughing the light soil to a depth of one foot with cattle, even though the area had previously been ploughed to six inches.

Chiselling the furrows in a wet area.

The area of upper land on which this experiment was laid down has been subject to erosion. The topsoil now averages six inches in depth. It is underlain by a compact, partially weathered subsoil.

The experimental site was 'close' ploughed to the full depth of the topsoil and furrowed. On one-half of the total number of plots the furrow bottoms were left unworked. On the remaining plots the furrow bottoms were opened by means of a chisel (knife) which penetrated approximately six inches into the subsoil. These cultural operations were performed with cattle during the wet season.

The experiment consists of eight randomised blocks with two replicates of each treatment in each block. The yield data for the plant canes are recorded in Table II.

Table II.—Chiselling the furrows in relation to yield of plant canes on a shallow soil of the upper lands.

Area: Wet. *Estate*: Molineux.
Variety: B.H. 10 (12).
Ploughed: Sept., 1934. *Chiselled*: Sept., 1934.
Planted: 19/9/34. *Reaped*: 31/3/36.
Rainfall (18½ months): 91 inches.
Layout: Randomised blocks.

Treatment of furrow bottoms.	Yield of plant canes* (tons per acre).
Unworked	34.52
Chiselled to 6 inches	34.46

* Mean yields for 16 replicates.

It is unlikely that six inches of soil are adequate for maximum growth of the plant under the conditions of adequate rainfall which obtained. *Nevertheless no gain in yield resulted from chiselling the furrow bottoms.*

It is doubtful whether the operation was performed in circumstances necessary for its success. *Chiselling can be expected to give satisfactory results only when the soil is dry for its value depends on its shattering action which loosens the soil.* If the operation is performed during the wet season when the soil is moist, as in the case of this experiment, the chisel merely cuts through the soil and the narrow opening thus formed closes during the next rains.

When dry the subsoil of the upper lands is too compact and resistant to be shattered by a cattle-drawn chisel. Mechanical power is probably essential to obtain full benefit from the operation.

Cross-Holing in a Wet Area.

It is still the general practice in St. Kitts to form bars of earth (cross-bars) at regular intervals across the furrows. The cane is planted in the cross-holes thus formed. The demerits of this practice have previously been described (4). In its favour it is stated that the cross-bars aid in the prevention of soil wash and that the cross-holes form natural receptacles for water from showers during dryish periods.

Critical information in relation to the effect on yield of plant canes of cross-holing the furrows in an area of the upper lands of St. Kitts is now available from one experiment. The experiment was laid down in the form of eight randomised blocks with two replicates of each treatment in each block. The yield data are summarised in Table III.

Table III.—Cross-holing the furrows in relation to yield of plant canes on the upper lands.

Area: Wet. *Estate*: Mansion.
Cross-holed: Oct., 1934. *Variety*: B.H.10 (12).
Planted: 23/10/34. *Reaped*: 25/3/36.
Rainfall (17 months): 77 inches.
Layout: Randomised blocks.

Treatment.	Yield of plant canes* (tons per acre).
Open furrows	40.21
Cross-holed furrows	39.45

* Mean yields for 16 replicates.

Cross-holing the furrows led to a small loss in yield in this experiment. Experiments reaped in Antigua in 1935 (4) and 1936 have given a similar result. If cross-holes aid in collecting water around the stools during dryish periods the increase in moisture concentration definitely does not appear to be associated with gain in yield of cane.

It is open to doubt whether it is fundamentally sound to cross-hole in order to prevent soil wash on the upper lands. Contour-furrowing serves this purpose far more efficiently. If contour-furrowing is practised it follows from the data recorded in Table III and elsewhere (4) that cross-holing is unnecessary. If contour-furrowing is not practised, cross-holing prevents a rush of water down the furrows provided that the rainfall is not excessively heavy, but when the cross-holes become filled with water the cross-bars are liable to collapse. Contour-furrowing without cross-holing is now successfully preventing soil wash on certain steep hillsides of St. Kitts in circumstances under which cross-holing without contour-furrowing has been found unsatisfactory.

Cultural Treatment of Ratoons in a Dry Area.

On the clay soils of Trinidad no immediate or cumulative gain in yield has been found to result from mechanical or hand tillage of ratoon canes unless too fine a tilth has been given to the soil during the cultural operations prior to planting (5). The effect of tillage on yield of ratoon canes on sandy soils is therefore a matter of interest.

Four treatments were included in a test which was carried out with first ratoon canes on a deep, fertile soil in a dry area of the lower lands. In the first treatment the stools of cane were moulded, the trash being allowed to lie with the minimum of disturbance. In the second the trash was ranged along alternate rows (between the lines of stools) and the rows thus laid bare were tilled. The trash was reversed (*i.e.* removed to the tilled rows) and the remaining rows also were tilled in

the third treatment. The fourth treatment was identical with the third except that half the trash was returned to the rows left bare. The tillage operation was performed on three occasions at fortnightly intervals by a mule-drawn cultivator working to a depth of about three inches.

The first treatment has already been adopted as standard by some estates. The second is at present the most generally favoured. The third is confined to a few areas, while the fourth is rarely practised.

The layout of the experiment was in the form of seven randomised blocks. The yield data are set out in Table IV. The comparatively low yields are due primarily to low and ill-distributed rainfall.

Table IV.—Effect on yield of cultural treatment of first ratoon-canes in a dry area of the lower lands.

Area: Dry. *Estate*: Buckleys.
Variety: B.H. 10 (12), first ratoons.
Reaped: March 1935, as plants; 26/2/36 as first ratoons.
Rainfall (11½ months): 41 inches.
Layout: Seven randomised blocks.

Cultural treatment of first ratoons.	Yield of cane (tons per acre).
(1) Stools moulded, trash undisturbed	20.48
(2) Trash ranged on alternate rows, and bare rows tilled	20.43
(3) As Tr. (2), but trash reversed and remaining rows tilled	20.00
(4) As Tr. (3), but half the trash returned to bare rows....	19.18

The data confirm the results of a preliminary cultural trial laid down in 1933 in a dry area of St. Kitts (6). *In the circumstances of the experiment there is no evidence that tillage of ratoons, apart from moulding the stools, leads to gain in yield.* The experiment is worthy of repetition in the wet areas of the island.

Mulching Experiments.

Use of Megasse for Moisture Conservation in the Dry Areas.

Time and method of application of the mulch.

The benefits which may be derived in the dry areas from the use of megasse as a soil cover for the conservation of moisture, rather than as material for the preparation of pen manure, have been discussed in an earlier paper of this series (2).

Preliminary information with regard to method of application of a mulch of megasse, and the comparative value of such a mulch for plant canes and ratoons, was obtained from four experiments reaped in 1935 (2). A fifth experiment of this series has now been harvested in which three general problems in relation to yield of plant canes were together under examination.

(i) Time of application of the mulch.

Two times of application were selected. In one the mulch was applied shortly before the end of the wet season when the soil was still saturated with water. The time actually chosen was nine weeks after planting, *i.e.*, during the second half of December. In the other the mulch was applied shortly after the beginning of the dry season, when the soil was drying out. In this case the time of application was 14 weeks after planting, *i.e.*, during the end of January and early February. The interval between the two times was therefore five weeks.

(ii) Thickness of the mulch.

The gains in yield from mulches two inches and three inches in thickness were compared.

(iii) Method of spreading the mulch.

On half of the plots the mulch was spread along alternate rows between the lines of stools. On the other half it was spread along every row.

The data given by this experiment are summarised in Table V. The variety of cane is B.H. 10 (12). The unsuitability of this variety to the dry areas in part accounts for the low yields.

Time of application of the mulch.

Perhaps the most important conclusion to which the experimental data give rise concerns the time of application of the mulch to the soil. The average gain in yield to the acre of 3.72 tons of plant canes obtained by mulching before the end of the wet season is more than double the average gain of 1.68 tons obtained by waiting until the dry season had set in. This conclusion holds whether the mulch was applied to alternate rows (in which case the average gain was 2.77 tons for early mulching and 1.34 tons for later mulching) or to every row (4.67 tons and 2.02 tons). *To obtain maximum gain from mulching on the light soils of the island it appears essential for the operation to be completed before the beginning of the dry season while the soil is still saturated with water.*

The relationship between time of mulching and gain in yield of plant canes under the conditions of the experiment is set out in graphical form in Figure I.

Thickness of the mulch.

The average gains given by early application of a two-inch mulch and a three-inch mulch were 3.66 tons and 3.77 tons of plant canes. The corresponding gains for later application were 1.98 tons and 1.38 tons. *There is nothing to choose between the effects on yield of the plant canes of mulches two inches and three inches in thickness whether the mulch was applied early or late.* This conclusion is in complete agreement with the results of the mulching experiments on plant canes of variety S.C. 12/4 reaped in 1935 (2).

Table V.—Effect of time and method of mulching with megasse on yield of plant canes.

Area: Dry. *Estate*: Needsmust. *Variety*: B.H. 10(12).
Planted: 19/10/34. *Reaped*: 1/3/36. *Rainfall* (16½ months): 68 inches.
Layout: Two 5 × 5 Latin squares.

YIELDS ARE EXPRESSED AS TONS CANE PER ACRE.

Treatment with Megasse.		Time of Application of Mulch.				Average gain (all plots).
Thickness of mulch.	Method of spreading.	Before end of wet season.		After beginning of dry season.		
		Yield.	Gain.	Yield.	Gain.	
Nil	—	15.96	—	14.25	—	—
2 inches	Alternate rows	19.21	3.25	15.96	1.71	
			2.77		1.34	2.05
3 inches	Alternate rows	18.25	2.29	15.21	0.96	
2 inches	Every row	20.04	4.08	16.50	2.25	
			4.67		2.02	3.34
3 inches	Every row	21.21	5.25	16.04	1.79	
Average gain from mulching		—	3.72	—	1.68	—

Method of spreading the mulch.

The average gain in yield of plant canes which resulted from spreading the mulch along alternate rows between the lines of stools was 2.05 tons to the acre. The gain of 3.34 tons from spreading the mulch along every row is significantly larger. The amount of megasse to the acre required by the former procedure is 50 per cent. of that required by the latter, whereas the gain was 60 per cent. as large. *Under the conditions which obtained, therefore, the gain per unit amount of megasse is proportionately somewhat greater when the material is spread along alternate rows rather than along every row.* This conclusion is independent of the time of application of the mulch.

The relationship found to obtain between methods of spreading the mulch and gain in yield of plant canes is graphically illustrated in Figure I.

In the preliminary mulching experiments (2) the gain resulting from spreading the mulch along every row was proportionately the greater. It will be recollected that these early experiments were not completed satisfactory and that the mulch was not applied until the soil was very dry.

A large estate in St. Kitts receives from the factory about 8,000 to 9,000 bales of megasse a year. About 200 bales to the acre are required for a two-inch mulch on alternate rows. Such an estate would be able to mulch in this way at least 40 acres of young plant canes in its dry areas. If a three-inch mulch is applied to ensure that weed growth under the mulch is completely smothered (2), alternate rows could be covered over an area of 27 to 30 acres. A sufficient supply of megasse is therefore available to assist materially in a mulching programme.

Manurial Experiments.

Use of Lime.

Immediate and residual effects of local slaked lime.

The experiment (2) laid down on the upper lands of Mansion Estate, in which the effects on yield of cane of regularly increasing dressings of slaked lime, locally burnt, are under measure, has now been reaped as plant canes and first ratoons. The yield data are summarised in Table VI.

Table VI.—Immediate and residual effects on yield of increasing dressing of local slaked lime on the upper lands.

Area: Wet. *Estate*: Mansion.
Variety: B.H. 10(12).
Limed: 21/11/33. *Planted*: 23/1/34.
Reaped: 5/6/35 as plants, 22/5/36 as first ratoons.
Rainfall: 69 inches as plants (16½ months),
55 inches as first ratoons (12½ months).
Layout: Two 4 × 4 Latin squares.

YIELDS ARE EXPRESSED AS TONS CANE PER ACRE.

Slaked lime per acre (1933).	Plants (1935).		1st Ratoons. (1936)		Total gain to date.
	Yield	Gain.	Yield.	Gain.	
Nil	38.19	—	31.21	—	—
1.55 tons	40.66	2.47	32.25	1.04	3.51
3.10 tons	42.03	3.84	34.69	3.48	7.32
4.65	43.75	5.56	36.77	5.56	11.12
Average gain....	—	3.96	—	3.36	7.32

The gains in yields of plant canes and of ratoons resulting from liming are large. They might be due to chance less than once in 100 times. The total gains for the two crops increase fairly regularly with increasing dressings of lime. As there is little to choose, on the average, between the magnitude of the immediate gains and first residual gains in yield, *it is probable that the beneficial effects of the dressings will continue over a number of future crops* (5, 7).

The lime requirement of the experimental area has been found on accurate re-measurement to be equivalent to 7.5 tons of calcium carbonate to the acre. The maximum dressing of slaked lime used in the experiment is therefore less than the lime requirement of the soil.

In a similar experiment laid down at Parsons Estate dressings of local slaked lime as large as 4½ tons to the acre gave rise to no change in yield of plant canes or first ratoons. It is probable that the soil of this experimental area is not in need of lime.

Immediate effects of ground limestone.

The slaked lime available from local sources is not a product of high quality (2). For this reason trials have been laid down with imported ground limestone 60 to 70 per cent. of which passes through a 100 mesh B.S. sieve. Limestone of this degree of fineness has been shown to give excellent results elsewhere (7).

Yield data for the first crop of canes reaped in trials with size of dressing of ground limestone at Milliken and Parsons Estates are recorded in Tables VII and VIII.

Table VII.—Immediate effects on yield of increasing dressings of ground limestone.

Area: Wet. *Estate*: Milliken.
Limed: 7/10/34. *Variety*: B.H. 10(12)
Planted: 19/10/34. *Reaped*: 17/4/36.
Rainfall: Not available.
Layout: Twelve randomised blocks.

Limestone per acre (1934).	Yield of plants tons per acre (1936).	Immediate gain.
Nil	40.01	—
2 tons (0.6 L.R.)	41.82	+ 1.81
4 tons (1.2 L.R.)	41.48	+ 1.47
6 tons (1.8 L.R.)	38.76	− 1.25

The soil of the experimental area at Milliken Estate contains 53 per cent. coarse sand, 14 per cent. fine sand, 13 per cent. silt and 13 per cent. clay. Its lime requirement is 3.3 tons of limestone to the acre. All plots were given to the acre basal dressings of 6 cwts. of sulphate of ammonia and 2 cwts. of muriate of potash.

The yield of plant canes on the unlimed plots is 40.01 *tons to the acre. At the dressing of limestone equal to* 0.6 *the lime requirement the yield rises to* 41.82 *tons. At* 1.2 *times the lime requirement there is a fall in yield to* 41.48 *tons. At* 1.8 *times the lime requirement there is a further fall to* 38.76 *tons, a value below that for the unlimed plots.*

The relationship between size of dressing of limestone and yield of cane is graphically illustrated in Figure II. If the curve is represented by an equation of the form $Y=A+B\xi_1,+C\xi_2$, *it can be shown that the rise and fall in yield are statistically significant and that maximum yield lies at a dressing equal to about* 0.8 *the lime requirement of the experimental area.*

A rise and subsequent fall in yield of cane, with a maximum in the region of the lime requirement, is known to occur in certain circumstances on heavy clay soils as the dressing of lime increases (7). It is of interest that a similar rise and fall can also obtain on light sandy soils.

The method of measurement of lime requirement used in these experiments has been described elsewhere (8).

Table VIII.—Immediate effects on yield of increasing dressings of ground limestone on the lower lands.

Area: Wet. *Estate*: Parsons.
Limed: 22/9/34. *Variety*: B.H.10(12).
Planted: 3/10/34. *Reaped*: 18/2/36.
Rainfall (16½ months): 86 inches.
Layout: Three 4 × 4 Latin Squares.

Limestone per acre (1934).	Yield of plants tons per acre (1936).	Loss in yield t.p.a.
Nil	38.39	—
2 tons	38.09	0.30
4 tons	36.10	2.29
6 tons	36.45	1.94

The basal manurial treatment was identical with that given to the corresponding plots at Milliken Estate.

This experiment was laid down alongside of the experiment with slaked lime at Parsons Estate. The dressing of 2 tons of ground limestone to the acre led to a small loss in yield. The dressings of 4 tons and 6 tons caused losses which might be due to chance less than once in 100 times. These data provide additional proof that the area under examination is not in need of lime. *Further, they confirm the conclusion that liming to unnecessary excess can have an adverse effect on yield of cane.*

It is noteworthy that a dressing of 4½ tons of local slaked lime caused no change in yield whereas 4 tons of imported ground limestone led to a significant loss in yield in the experiments at Parsons Estate. It would seem that the finely

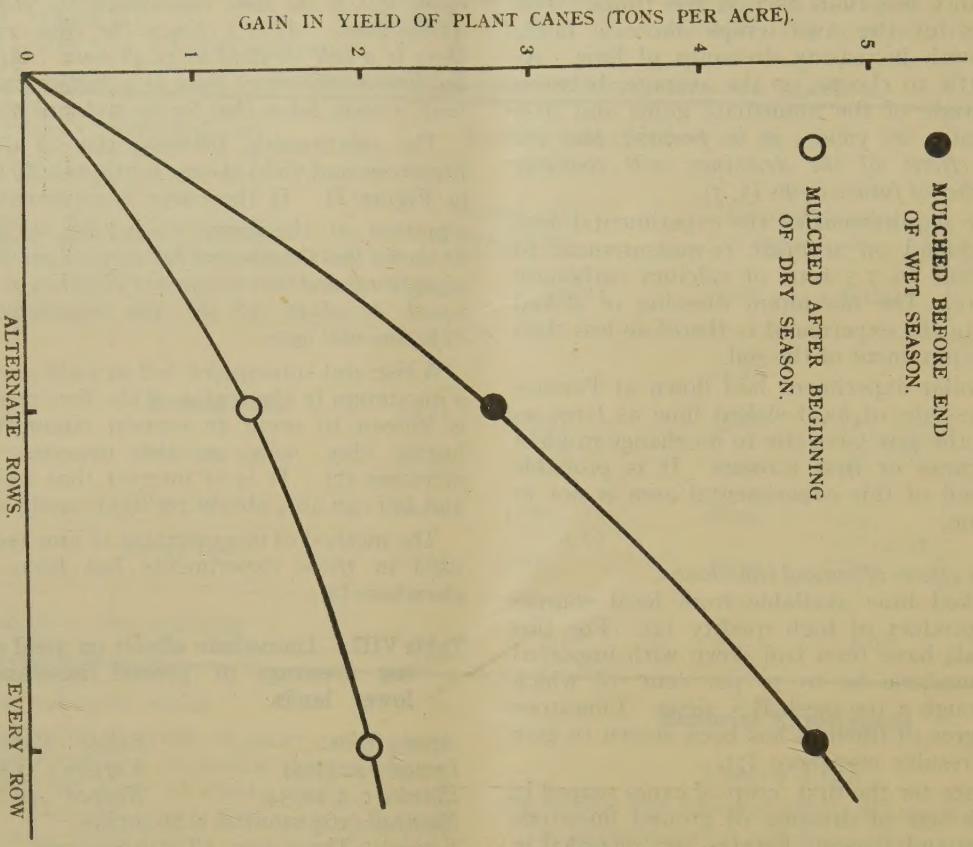

FIG. I.—EFFECT OF TIME AND METHOD OF APPLICATION OF A MULCH OF MEGASSE ON YIELD OF PLANT CANES IN A DRY AREA.

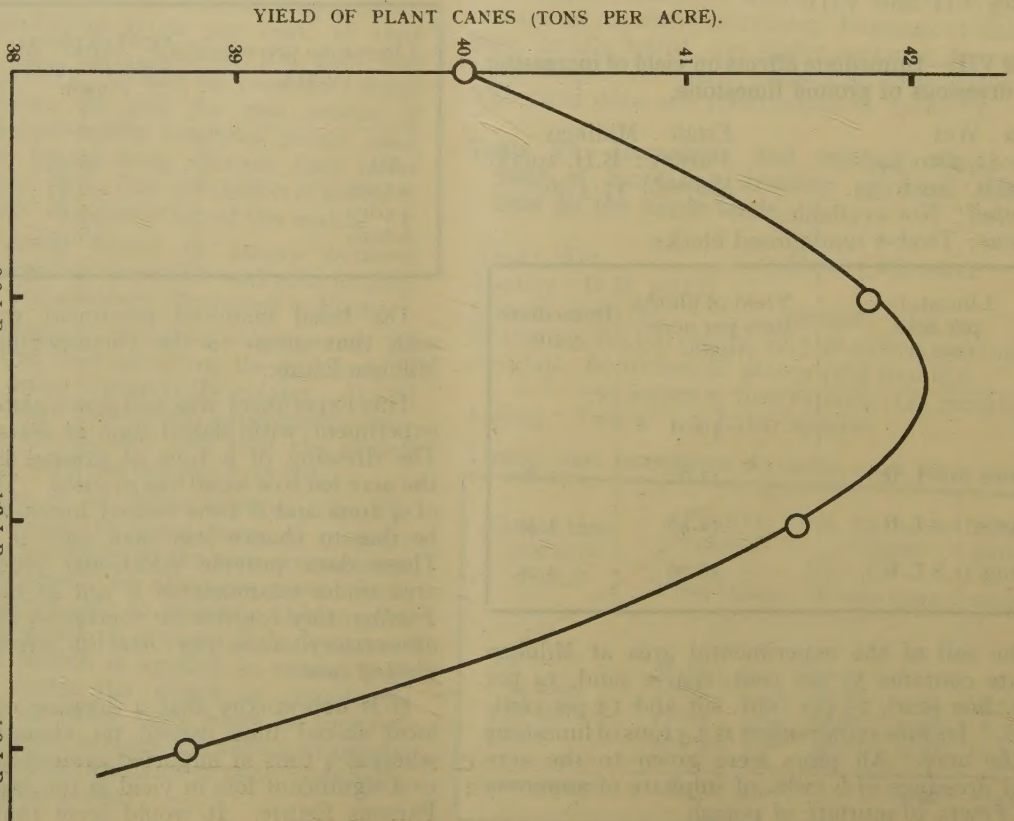

FIG. II.—EFFECT OF INCREASING MANURIAL TREATMENT WITH GROUND LIMESTONE ON YIELD OF PLANT CANES ON A LIGHT SANDY SOIL.

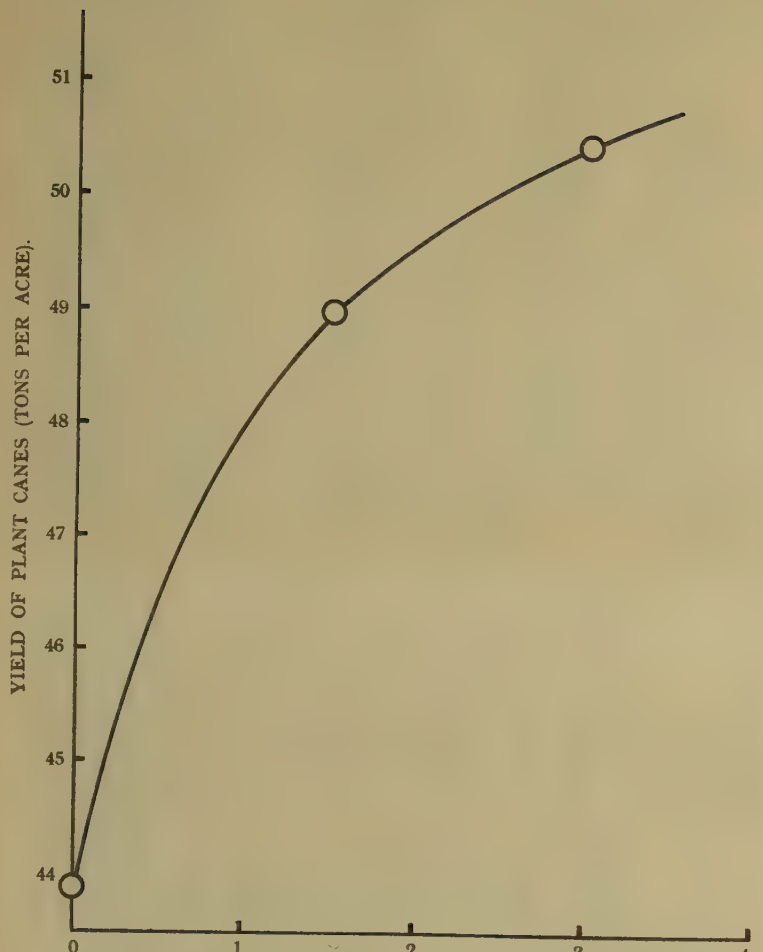

FIG. III.—EFFECT OF SIZE OF EARLY DRESSING OF SULPHATE OF AMMONIA ON YIELD OF PLANT CANES IN A WET AREA. ALL PLOTS WERE GIVEN 3 CWTS. OF SULPHATE OF AMMONIA TO THE ACRE 8 TO 9 MONTHS AFTER PLANTING.

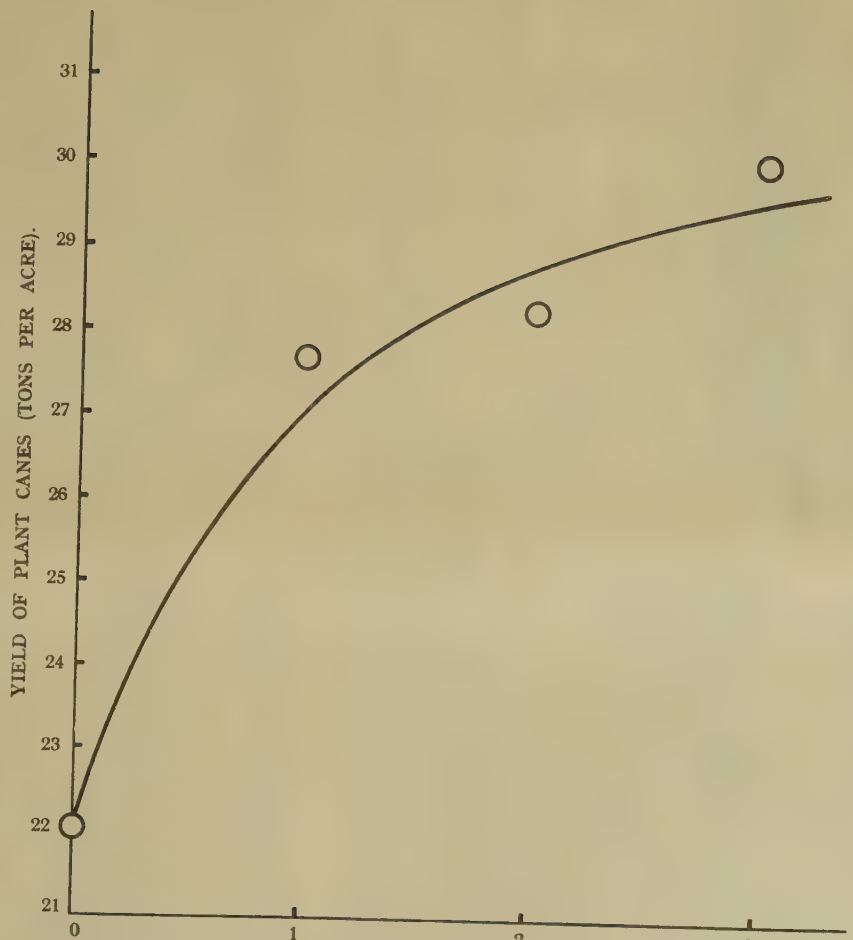

FIG. IV.—EFFECT OF SIZE OF EARLY DRESSING OF POTASH ON YIELD OF PLANT CANES IN A WET AREA. THE SOIL CONTAINS 76 PARTS PER MILLION OF AVAILABLE (EXCHANGEABLE) POTASH.

divided imported material is more reactive and consequently more readily available to the plant than the coarser local product.

Discussion.

The information obtained from these liming experiments serves to exemplify the benefit which can be derived from the scientifically controlled use of lime on acid soils and of the loss which can arise from its haphazard use. It provides concrete evidence of the urgent need for a field to field survey of the lime requirements of the soils of St. Kitts (1). A survey of this kind (9), linked with a critical scheme of field experiments (7), has been in operation on a number of sugar estates in Trinidad for some years. The survey and the experiments are together proving of inestimable value to that island, for they enable precise and detailed recommendations as to the optimum dressing of lime for maximum financial gain under the particular circumstances of each individual field.

Use of Nitrogen.

Early dressings of sulphate of ammonia to plant canes.

Measures of the effects on yield of cane of a dressing of one cwt. of sulphate of ammonia applied at the time of planting, and of dressings of 1½ cwts. and 3 cwts. applied six to eight weeks after planting, in a wet area and in a dry area are summarised in Table IX.

Table IX.—Effect of early dressings of sulphate of ammonia on yield of plant canes.

Area:	Wet.	Dry.
Estate:	Estridges.	West Farm.
Variety:	B.H.10 (12).	B. 2935.
Planted:	1/11/34.	17/10/34.
Reaped:	28/5/36.	17/3/36.
Rainfall:	75 inches (19 months).	59 inches (17 months).

Layout: One 6 × 6 Latin square at each site.

Sulphate of Ammonia per Acre in 1934.		Yield of Plants in 1936 (tons per acre.)	
At planting.	6-8 weeks later.	Wet area.	Dry area.
Nil	Nil	43.90	34.03
Nil	1½ cwts.	48.99	33.68
Nil	3 cwts.	50.51	33.01
1 cwt.	Nil	48.07	34.35
1 cwt.	1½ cwts.	48.48	31.73
1 cwt.	3 cwts.	52.08	33.63

All plots in both experiments were given a basal dressing of 3 cwts. of sulphate of ammonia to the acre towards the end of the dry season of 1935 *(i.e., eight to nine months after planting)*, and of phosphate and potash six to eight weeks after planting.

The rainfall on the experimental areas during the first nine months of the life of the plants is recorded in Table X.

Table X.—Rainfall in inches during the first nine months after planting in the experiments with early dressings of sulphate of ammonia.

Month.	Wet area.	Dry area.
November (1934)	7.42	8.19
December	4.30	4.78
January (1935)	3.47	1.94
February	2.18	1.77
March	1.38	0.82
April	2.10	1.08
May	3.07	0.62
June	2.84	3.60
July	6.27	3.88
Total	33.03	26.68

Wet area.

In the wet area the dressing of one cwt. of sulphate of ammonia at planting led to a significant gain in yield of 4.17 tons of cane, provided that no nitrogen was applied six to eight weeks later. *In the presence of this later dressing, the dressing at planting would appear unnecessary for the gain to which it gave rise was reduced to* 0.53 *tons.*

Applications of 1½ cwts. and 3 cwts. of sulphate of ammonia six to eight weeks after planting, in the absence of nitrogen at planting, led to gains in yield of 5.09 and 6.61 tons of cane, respectively. These gains might be due to chance far less than once in 100 times.

The relationship between size of dressing of sulphate of ammonia, when applied six to eight weeks after planting, and yield of cane is expressed in graphical form in Figure III. *Under the conditions of the experiment it would appear that a dressing as large as 3 cwts. to the acre can be used with advantage during this period in the early life of plant canes even though an additional 3 cwts. to the acre is given towards the end of the dry season which follows.*

The canes on the plots which received dressings of sulphate of ammonia as heavy as 4 cwts. to the acre within the first two months after planting showed no signs of drying out although the experiment was not harvested until the end of the crop season.

Dry area.

In the dry area there was ample rainfall during the early stage of growth for the young plants to make full use of the light dressing of sulphate of ammonia applied at the time of planting. *Nevertheless, no gain in yield resulted from this dressing even on the plots which did not receive further nitrogen until eight or nine months after planting.*

Also, the dressings of sulphate of ammonia applied six to eight weeks after planting gave rise to no gain in yield. It would appear unlikely from a comparison of the rainfall data recorded in Table X for the wet and dry experimental areas that the lack of response is due only to an inadequate supply of moisture. It is probable that the high degree of fertility of the particular area under experiment is a contributory factor.

A similar experiment laid down at Cranstouns Estate gave results identical in kind with those obtained at West Farm.

Early and late dressings of sulphate of ammonia to ratoon canes.

Measures of the effects of early and late dressings of sulphate of ammonia to first ratoon-canes in a wet area and in a dry area are set out in Table XI.

Table XI.—Effect of early and late dressing of sulphate of ammonia on yield of first ratoons.

Area: Wet.	Dry.
Estate: Belmont.	Caines.
Variety: B.H. 10(12).	B.H. 10(12).
Reaped as plants: May 1935.	15/5/35.
Reaped as 1st R. 12/5/36.	15/5/36.
Layout: Seven randomised blocks.	Two 5 × 5 Latin squares.

Sulphate of Ammonia per Acre in 1935.		Yield of 1st R. in 1936 (t.p.a.)	
Mid July.	Early Oct.	Wet area.	Dry area.
Nil	Nil	20.41	34.72
2 cwts.	Nil	27.26	37.38
3 cwts.	Nil	27.68	38.49
2 cwts.	2 cwts.	28.24	37.04
3 cwts.	2 cwts.	29.71	37.05

Wet area.

The experimental area was given a light dressing of pen manure and 2 cwts. of sulphate of ammonia to the acre as plant canes.

Treatment of the ratoon canes with 2 cwts. and 3 cwts. of sulphate of ammonia about one month after reaping the plants led to gains in yield of 6.85 and 7.27 tons of cane, respectively. These gains might be due to chance less than once in 100 times. *Under the conditions of the experiment the optimum early dressing of sulphate of ammonia to ratoons would appear to be 2 cwts. to the acre although it is probable that 3 cwts. would in general give more paying results in the wet areas.*

The additional gain resulting from further treatment with 2 cwts. of this manure after an interval of ten weeks was small and not statistically significant. *It is doubtful whether a late dressing of sulphate of ammonia to ratoon canes is worth while, provided that an early dressing is applied, although the late dressing may have a residual effect on the following crop.*

Dry area.

The experimental area received basal dressings to the acre of 25 tons of pen manure and 3 cwts. of sulphate of ammonia as plant canes.

In the dry area early treatment of the ratoons with 2 cwts. and 3 cwts. of sulphate of ammonia gave rise to significant gains of 2.66 and 3.77 tons of cane, respectively. *Gains of this magnitude are subnormal and it is possible that the dressings will have a residual effect on the second ratoons.* The additional late dressings had no immediate beneficial effect on yield.

Use of Phosphate.

Early dressings of superphosphate to plant canes.

Preliminary measures of the effects on yield of cane of dressings of one cwt. of superphosphate applied at the time of planting and 2 cwts. applied two months later are now available for wet areas of the upper and lower lands. The data obtained are recorded in Tables XII and XIII.

Table XII.—Effects of early dressings of superphosphate on yield of plant canes on the upper lands.

Area: Wet. *Estate*: Lynches.
Variety: B.H. 10(12).
Planted: 2/11/34. *Reaped*: 7/4/36.
Rainfall (17¼ months): Not available.
Layout: Two 4 × 4 Latin squares.

Superphosphate per acre.		Yield of cane (t.p.a.)	Gain (t.p.a.)
At planting.	2 months later		
Nil	Nil	31.05	—
Nil	2 cwts.	33.16	2.11
1 cwt.	Nil	34.15	3.10
1 cwt.	2 cwts.	33.85	2.80

All plots were given basal dressings of sulphate of ammonia and muriate of potash.

There is nothing to choose between the gains in yield resulting from the three dressings of superphosphate to this area of the upper lands. Each gain might be due to chance less than once in 100 times. *Under the conditions of the experiment the optimum dressing would appear to be one cwt. to the acre, applied very early in the life of the plant.**

To place the results of this experiment in true perspective it should be noted that generous dressings of fish manure, which contains phosphate,

* Inorganic manures added at the time of planting, or shortly afterwards, can have an adverse effect on germination if they are placed too near the sett (10). Care should therefore be taken to put them in the furrows a short distance away from the sett, and in a position such that they cannot be washed on to the sett by rain.

were applied to the two previous crops of cane reaped on the area. It would therefore appear to pay to apply phosphate to successive crops on soils deficient in this plant food.

Table XIII.—Effects of early dressings of superphosphate on yield of plant canes on the lower lands.

Area: Wet. *Estate*: Belmont.
Variety: B.H.10 (12).
Planted: 12/10/34. *Reaped*: 7/3/36.
Rainfall (17 months): 96 inches.
Layout: Three 4 × 4 Latin squares.

Superphosphate per acre.		Yield of cane (tons per acre.)
At planting.	6 weeks later.	
Nil	Nil	61.66
Nil	2 cwts.	60.75
1 cwt.	Nil	60.74
1 cwt.	2 cwts.	60.28

The experimental area was given basal dressings of pen manure, sulphate of ammonia and muriate of potash. No gain in yield of plant canes resulted from the treatments with phosphate.

Yield of plant canes in the island rarely exceeds 45 tons to the acre. In this experiment the yield was 60 tons. There is no obvious reason why yields as high as 60 tons should not be far more common in the wet areas, in view of the ample and well-distributed rainfall*. Progress in this direction will depend largely on improvements in cultural methods and more thorough understanding of the manurial requirements of the soil.

Use of Potash.

Early dressings of potash to plant canes.

Two experiments with potash on plant canes, laid down on unpenmanured upper lands, were reaped in 1935. In both significant gains in yield were obtained (2).

Four experiments on plant canes were harvested in 1936, one in a dry area of the lower lands, two in wet areas of the upper lands and one in a wet area of the lower lands. The results obtained are recorded in Tables XIV to XVII.

* In many of the wet areas of the island growth of the variety B.H. 10(12) is slow during the first four to six months of the life of the plant canes. A suitable variety, which makes more rapid early growth, should lead to an average increase in yield of plant canes of at least five tons to the acre in these wet areas.

Table XIV.—Effect of an early dressing of potash on yield of plant canes in a dry area of the lower lands.

Area: Dry. *Estate*: College.
Variety: S.C.12/4.
Planted: 25/11/34. *Reaped*: 11/2/36.
Rainfall (14¾ months): 55 inches.
Layout: Randomised blocks.

Muriate of potash per acre.	Yield of plant canes* (tons per acre).
2 cwts.	23.75
Nil	21.93
Gain from potash	1.82

* Mean yields for 16 replicates.

The layout of the experiment was in the form of eight randomised blocks with two replicates of each treatment in each block. All plots were given to the acre basal dressings of 3 cwts. of sulphate of ammonia six weeks after planting and 3 cwts. towards the end of the following dry season. The potash was applied six weeks after planting. The experimental area was not penmanured in 1934.

The gain of 1.82 *tons of plant canes to the acre resulting from treatment with potash might be due to chance less than once in* 100 *times.* An equally large gain of plant canes would probably have been obtained from a dressing of one cwt. of potash.

In the past the area under experiment has been regularly and heavily penmanured. It is of interest that continued treatment of this kind does not appear to have created a store of potash in the soil adequate for a crop of plant canes.

Table XV.—Effect of an early dressing of potash on yield of plant canes in a wet area of the upper lands.

Area: Wet. *Estate*: Molineux.
Variety: B.H. 10 (12).
Planted: 19/9/34. *Reaped*: 31/3/36.
Rainfall (18½ months): 91 inches.
Layout: Randomised blocks.

Muriate of potash per acre.	Yield of plant canes† (tons per acre).
1 cwt.	36.18
Nil	32.80
Gain from potash	3.38

† Mean yields for 16 replicates.

This experiment also was laid out in the form of eight randomised blocks with two replicates of each treatment in each block. All plots received basal dressings to the acre of one cwt. of sulphate of ammonia at planting, 2 cwts. seven weeks after planting and 3 cwts. early in the following wet season. Pen manure was not applied.

The topsoil of the experimental area is about six inches in depth. It contains 113 parts per million of available (exchangeable) potash as K_2O.

The treatment with one cwt. of muriate of potash led to an increase in yield of plant canes of 3.38 *tons.* This gain might be due to chance less than once in 100 times.

Table XVI.—Effect of size of early dressing of potash on yield of plant canes in a wet area of the upper lands.

Area: Wet. *Estate*: Mount Pleasant.
Variety: B.H. 10 (12).
Planted: 2/11/34. *Reaped*: 6/5/36.
Rainfall: Complete returns not available.
Layout: Seven randomised blocks.

Muriate of Potash per acre.			Yield of plants (t.p.a.)	Gain in yield (t.p.a.)
At planting.	10 weeks later.	Total dressing.		
Nil	Nil	Nil	22.04	—
1 cwt.	Nil	1 cwt.	27.69	5.65
Nil	2 cwts.	2 cwts.	28.28	6.24
1 cwt.	2 cwts.	3 cwts.	30.06	8.02

The experimental area was given basal dressings to the acre of one cwt. of sulphate of ammonia at planting, 2 cwts. ten weeks after planting and 3 cwts. early in the following wet season. Superphosphate was applied to all plots at the rate of 2 cwts. to the acre ten weeks after planting. No pen manure was used.

The area has been subject to severe erosion and the soil is now shallow. The topsoil contains 76 parts per million of available (exchangeable) potash as K_2O.

The gains in yield of plant canes resulting from the treatments with potash are large. They might be due to chance far less than once in 100 times. Further, they increase significantly as the total dressing increases. The relationship between size of total dressing and yield is set out in the form of a graph in Figure IV. The optimum economic early dressing of potash to plant canes under the conditions of the experiment would appear to be in the region of 2 cwts. to the acre.

Table XVII.—Effect of early dressings of potash on yield of plant canes in a penmanured area of the lower lands.

Area: Wet. *Estate*: Willetts.
Variety: B.H. 10(12).
Planted: 4/10/34. *Reaped*: 12/3/36.
Rainfall (17¼ months): 100 inches.
Layout: Three 4 × 4 Latin squares.

Muriate of Potash per acre.		Yield of plants.	Average gain.
At planting.	7 weeks later.		
Nil	Nil	37.31	—
1 cwt.	Nil	37.29	
Nil	2 cwts.	37.69	0.44
1 cwt.	2 cwts.	38.26	

The experimental area was given a basal dressing of 25 tons of pen manure to the acre before planting. All plots received basal sulphate of ammonia and superphosphate.

Only a small gain in yield resulted on the average from treatment with potash. The trend of the data suggest that the dressing of pen manure contained just enough readily available potash for the crop of plant canes.

The topsoil of the experimental area contains 84 parts per million of available (exchangeable) potash as K_2O.

Discussion.

Five experiments with potash on unpenmanured plant canes have now been reaped in all. They were well distributed throughout the cultivated areas, namely at Bourkes, Mount Pleasant, Hope, Molineux and College Estates. In each case there has been a significant response to this manure. It would seem likely, therefore, that a large proportion of the soils of the island are deficient in potash.

The five experiments are intended to form the first links in a chain of trials. When sufficient yield and soil data become available from these trials it should be possible to find a relationship between the amount of available potash in the soil and response to treatment (5, 9) which will enable definite recommendations with regard to size of dressing of potash for optimum gain according to the particular circumstances which obtain. A field-to-field survey of the potash status of the soil would be necessary for the purpose.

Use of Molasses as a Manure.

Immediate and residual effects of molasses on yield.

An experiment was laid down in 1933 on an area of the lower lands to measure the effect on yield of dressings of molasses. The amounts under test were 2½ pints and 5 pints to the cross-hole (*i.e.* 3.15 tons and 6.30 tons to the acre). The molasses was applied in the cross-holes and lightly covered with earth one month before planting.

No inorganic manures were given to the plant canes. The ratoons received a basal dressing of sulphate of ammonia.

The molasses was found to have an adverse effect on germination of the plant canes which increased significantly with the size of dressing. The relationship between treatment and germination is recorded below.

Dressing of molasses.	Germination (per cent.)
Nil	92
3.15 tons per acre	86
6.30 tons per acre	80

The yield data for the plant-cane and first-ratoon crops are summarised in Table XVIII.

Table XVIII.—Immediate and residual effects on yield of increasing dressings of molasses on the lower lands.

Area: Intermediate. *Estate*: Estridges.
Variety: B.H. 10 (12).
Molasses applied: 24/1/34. *Planted*: 20/2/34.
Reaped: 24/5/35 as plants; 28/4/36 as first ratoons.
Layout: Six randomised blocks.

Yields of Cane are expressed as tons per acre.

Molasses per acre (1933).	Plants (1935).	1st R. (1936).	Gain (to date.)
Nil	37.17	33.69	—
3.15 tons	39.13	36.32	4.59
6.30 tons	37.77	35.84	2.75

The immediate effect of treatment with molasses on the plant canes is not statistically significant. The yield of plants on the plots with the heavier dressing is somewhat smaller than on the plots with the lighter dressing probably because of the poorer germination.

The residual effect of the treatment on the ratoon canes approximates to statistical significance. The gain in yield of ratoons can be shown to be due to the potash which the molasses contains.

The experimental data give no indication that it would pay to use molasses as a manure on the lower lands.

General.

Since the inception of the experimental scheme towards the end of 1933 there has been a considerable increase in the amount of sulphate of ammonia applied to sugar-cane in St. Kitts, and a commencement has been made in the use of inorganic phosphate and potash. The total imports of inorganic manures during the crop years 1933-1936 are recorded in Table XIX. It is almost certain that there will be further considerable increases in the near future, as the value of inorganic manures becomes more fully realised and as knowledge of their use to maximum advantage becomes more complete.

Table XIX.—Imports of inorganic manures into St. Kitts since the inception of the experimental scheme.

Crop year.	Total imports of inorganic manures (tons).
1933	703
1934	1,102
1935	1,345
1936	2,334

The total imports of inorganic manures during the crop year 1932 was 706 tons.

Provided they are applied in proper balance, and that the soil is not allowed to become too acid, no fear need be entertained that inorganic manures destroy the fertility of the soil. On the contrary, the increase in yield of cane which results from their use is accompanied by a larger amount of trash which is returned to the soil and by a larger root system which is left in the soil to decompose. Data are available which prove that by these indirect means inorganic manures can raise the level of fertility of sugar-cane soils.

Summary.

There are recorded in this paper the results of a series of cultural, mulching and manurial experiments reaped in St. Kitts in 1936. The experiments were laid down under the auspices of the Sugar-Cane Investigation Committee of the island.

Cultural Experiments.

Under the existing conditions ploughing to a depth greater than six inches may be unnecessary on the deep sandy soils of the lower lands.

Chiselling (knifing) the furrow bottoms on a shallow soil of the upper lands in the wet season gave rise to no immediate gain in yield of plant canes.

Cross-holing the furrows on the upper lands has been found to lead to a small loss in yield.

Tillage of ratoon canes, apart from moulding the stools, appears to be unnecessary in the dry areas of the lower lands.

Mulching Experiments with Megasse.

To obtain maximum gain from mulching on the light soils of the island it appears essential for the operation to be completed before the beginning of the dry season while the soil is still saturated with water.

As large a gain in yield of plant canes can be obtained from a two-inch mulch of megasse as from a three-inch mulch.

A proportionately greater gain in yield of plant canes may be obtained per unit amount of megasse by spreading the material along alternate rows between the lines of stools rather than along every row.

Manurial Experiments.

Lime.

Dressings of slaked lime, locally burnt, have been found to give satisfactory gains in yield of plant canes and first ratoons on an acid soil of the upper lands. It is probable that the beneficial effects of the dressings on yield will continue over a number of future crops.

Indirect evidence has been obtained that finely ground limestone is more reactive and consequently more available to the plant than the slaked lime available from local sources.

It is shown that yield of plant cane is increased by manurial treatment with finely ground limestone until the size of dressing attains a limiting value which lies in the region of the lime requirement. At dressings above this value a serious fall in yield can occur.

The information obtained from the liming experiments demonstrates the urgent need for a field-to-field survey of the lime requirements of the soils of the island.

Nitrogen.

In an unpenmanured area it was found that a dressing as large as 3 cwts. of sulphate of ammonia could be given with advantage to plant canes six to eight weeks after planting, even though an additional 3 cwts. to the acre was applied eight to nine months after planting. Treatment with sulphate of ammonia at the time of planting may be unnecessary provided that the dressing six to eight weeks afterwards is adequate.

In two unpenmanured, dry areas no gain in yield of plant canes was derived from an application of sulphate of ammonia either at planting or six to eight weeks later.

A second and late dressing of sulphate of ammonia to ratoon canes gave rise to no additional gain in yield either in a wet area or in a dry area.

Phosphate.

In an unpenmanured area of the upper lands a very early dressing of one cwt. of superphosphate to plant canes gave rise to a satisfactory gain in yield. Generous dressings of fish manure, which contains phosphate, had been applied to the two previous crops reaped on the area.

Plant canes in a high-yielding, penmanured area of the lower lands gave no response to treatment with superphosphate.

Potash.

Five experiments on unpenmanured plant canes have so far been reaped. In each case a significant gain in yield resulted from treatment with potash which varied from 1.82 to 8.02 tons of cane according to circumstances. As these experiments were well distributed throughout the island it would appear that large areas of soil are deficient in potash. The need therefore arises for a field-to-field survey of the potash status of the soil to enable definite recommedndations as to optimum size of dressing of this manure.

Preliminary data obtained from a sixth experiment indicate that a dressing of 25 tons of pen manure contains enough readily available potash for a crop of plant canes.

Molasses.

It would not appear to pay to use molasses as a manure on the lower lands.

General.

There has been a considerable increase in the use of inorganic manures in the island since 1933, and further large increases are likely. No fear need be entertained that inorganic manures destroy the fertility of sugar-cane soils provided they are used in proper balance and the soil is not allowed to become too acid.

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STORAGE AND TRANSPORT OF TROPICAL FRUITS AND VEGETABLES.*

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Beans and Peas.

According to Krause (5) working in Sweden, French, Kidney or String beans (*Phaseolus vulgaris*), stored in loose heaps, remained in good condition for three weeks at 32° to 38°F. and R.H. of 85 per cent., but lost 20 per cent. of their weight during this period.

Only beans free from surface moisture and disease should be stored. Although a storage temperature of 32°F. has been recommended and is often used, Platenius *et al.* (7) have reported that beans keep longest in good marketable condition at 40°F. Humidity should be maintained at around 85 per cent. and hampers or other containers stacked so as to allow ample air circulation, otherwise the contents are likely to heat and decay. The accumulation of surface moisture during storage should be avoided. Beans kept too long are liable to become mouldy or slimy. Freezing injury is marked by irregular, water-soaked areas. Plank and Schneider (6) found that an average temperature of 2°C. (35.6°F.), a relative humidity of 90 per cent., and weak agitation of the air, were the conditions most favourable to the storage of French (Dwarf) beans and runner beans, an extended life of two weeks without important losses being assured.

String beans grown under tropical conditions in Trinidad (10), packed in standard 20 lb. crates and held at 45°F. and R.H. of 80 to 85 per cent. for 22 days, were found to possess good keeping quality at this temperature, provided excessive desiccation could be avoided. The following losses in weights in small lots wrapped in greaseproof paper were recorded: at 45°F. (R.H. 80 to 85 per cent.), 25 per cent. after 14 days and 39 per cent. after 22 days; at 50°F. (R.H. 80 per cent.), 27 per cent. after 14 days, 43 per cent. after 22 days; at 60°F. (R.H 75 to 80 per cent.), 38 per cent. after 14 days; at 80°F. (R.H. 55 to 95 per cent.), 78 per cent. after 14 days, 91 per cent. after 20 days. While string beans can lose a certain amount of moisture without impairing palatability, nevertheless, in harvesting and packing, every care should be taken to curtail desiccation.

Smith (8A), in storage trials with Jamaica-grown French beans at 40°F. and 50°F., observed that wilting was excessive and necessitated wrapping consigmnetns in waxed paper or cellophane; a temperature of 34° to 38°F., is considered to be more suitable. Long stringless varieties have not given satisfactory results in cold storage.

Lima beans (*Phaseolus lunatus*) in the pod can be stored three to four weeks at 32°F. Although the pods become more or less discoloured, presumably due to chilling and desiccation, the beans remain bright and clean and of good quality. Shelled limas if stored at this temperature should keep in good saleable condition for about 15 days. At a higher temperature, *e g.*, 50°F., they soon become mouldy (7, 8).

In experiments carried out by Jamison (4), peas (*Pisum sativum*) were stored in bushel baskets at temperatures ranging from 32° to 70°F.; at 32°F. and 40°F. they remained in good condition for more than two weeks, some loss in quality being observed at the higher temperature; at 50° and 70°F. eating quality showed obvious deterioration within a few days (4, 7). Rapid cooling, precooling with ice water, high humidity and abundant air circulation in the storage room have been advised (8). Plank and Schneider (6) recommend storage at 32°F., with R.H. of 80 to 90 per cent.: under these conditions losses of five per cent. after 25 days and ten per cent. after 32 days were recorded.

Williams (11) reports that beans and peas, as grown under New South Wales conditions, may be held in good condition for four weeks at a temperature of 33°F. and R.H. of 85 per cent.; the vegetables should be crated—not bagged—and adequate air circulation maintained in storage rooms.

A storage temperature of 45°F. has been cited for dry beans (3).

Gas Storage.

Some gas storage experiments with beans have been reported by Brooks *et al.* (2). The warm vegetables, at an initial temperature of 75° to 85°F. were gradually cooled down to 45°-55°F. (average 50°F.), solid carbon dioxide being supplied so as to give CO_2 concentrations of 20, 30 and 40 per cent., these concentrations falling to 10, 15 and 20 per cent. respectively, at the close of the experiments. Control samples were held at 32° and 40°F. without CO_2. The object of these tests was to improve preservation and control fungal wastage during the preliminary cooling period. After two days treatment the beans were removed to 70°F. No CO_2 injury was observed, and flavour was not impaired except in the case of snap beans exposed to 30 per cent. CO_2; of four storage fungi, two were inhibited by the gas treatment and two were not affected. Thornton (9) on the other hand has reported injury to stringless beans exposed for three days at 0°C. (32°F.) or 15°C. (59°F.) to atmospheres containing 18 per cent. CO_2.

Control of Weevils.

According to Back (1) weevils will not feed and cause damage to beans and peas at low temperatures. It is not known at what temperature

* Continued from *Tropical Agriculture*, XIV, 3, p. 83.

their development ceases, but no activity has been observed at or below 50°F. Cowpeas can be kept free from weevils if held in storage at a temperature of 32° to 34°F. It is claimed that exposure for a season at this temperature does not affect the germinating power of the seed. Investigations conducted in the United States indicate that no stage of the common bean weevil can withstand 56 days of cold storage at 31° to 32°F., although they may survive more than 66 days at 36°F. Larvae succumb to cold storage temperatures more readily than do pupae or adults. Storage rooms should be kept as dry as possible, the seeds being handled in sacks as in warehouses. Cowpeas held for a season at 32° to 34°F. did not lose their germinating power any sooner on removal to normal temperatures than cowpeas not thus exposed to cold. Seeds removed from cold storage to warm temperatures are likely to collect condensation moisture. Care should be taken to eliminate this surface moisture by drying or ventilation, otherwise mouldiness may result. In general, seeds can be protected more cheaply by fumigation under storage conditions which may be better for the seeds.

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Beet-Root.

Beets are well adapted to storage and may be kept for several months, at 32° to 40°F., provided their tendency to rapid wilting is controlled by maintaining a high humidity in the storage room. Platenius *et al.* (3) observed that sprouting began after three months at 50°F. With air-blast refrigeration, beets as grown in Trinidad showed excessive wilting at 40° and 45°F. Krause (2) cites a storage temperature of 32° to 33.5°F. as suitable for this root-crop. Immature bunch beets are more perishable and should only be stored temporarily (4). In gas storage experiments (1) using high concentrations of CO_2, no injury was observed, but no benefit accrued from the treatment.

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Breadfruit (Artocarpus incisa).

The transport of this fruit from Java to Holland in refrigerated chambers at 3°C. (37.4°F.) has been attempted (1).

1. Transport and Maturation of Tropical Fruits. *Rev. Scient. Illustr.* June 8, 1929. (*Abst. in Int. Bul. Inf. Refrig.*, X, p. 737.)

Cabbage, Cauliflower and Related Crops.

Although these crops are best suited to temperate climates, carefully selected varieties can be grown in the tropics with a fair measure of success. The acclimatisation of good, adaptable strains is desirable, even where the produce is intended for local consumption only.

Cabbage.

The solidity of the head, the colour of the crown and the curling back of the outer leaves are the usual criteria by which harvesting maturity is determined. Soft and immature heads tend to wilt badly, while over-ripe ones are too tender and brittle for long shipment (7).

Heads for shipment or storage should be carefully graded, and firmly packed, with the stems out, in crates. When stowed in bulk thorough ventilation is essential. According to Hauck (7) writing of United States produce, only Danish or Hollander cabbage can be stored without excessive shrinkage; an account is given by Corbett (4, 5) of the houses and racking arrangements used for this purpose. During cold storage, drip from the ceiling, and condensation of moisture on the leaves should be avoided. The temperature should be maintained as near 34°F.

as possible (4); 32°-35°F. (5), 32°-33°F. (14), 32°-36°F. (2), and 30.2°F. and R.H. of 90 per cent. (6) are also cited as suitable for the storage of cabbage over a period of three months. To prevent excessive wilting and shrivelling a high relative humidity is essential. Platenius *et al.* (12) have described storage trials at 32°, 40° and 50°F. A temperature of 32°F. proved most suitable, the heads only losing ten per cent. in weight during three months, and remaining in good condition for five months; at 40°F. deterioration was more rapid, giving a total storage life of three months; at 50°F. many heads became unmarketable during this period, mould, soft rot, wilting of the outer leaves, and burst heads reducing the weight of marketable crop by 50 per cent. Freezing injury in storage is to be avoided. For New South Wales produce Williams (18) found that heads wrapped prior to storage kept much better than unwrapped heads, giving a storage life, at 31°F. and R.H. of 85 per cent., of ten weeks as compared with six weeks. According to Brooks *et al.* (1) brief treatments with high concentrations of CO_2 did not affect cabbages either in respect of causing injury or modifying the flavour.

Cauliflower.

For successful storage it is necessary not only to prevent fungal wastage but also to retard the maturation of the head or curd. Heads may be cut before they are quite mature but with some loss in flavour as compared with fully grown heads. If cut under moist conditions, decay, due to superficial fungi, may occur during storage or transport. Commercial over-maturity is marked by a browning of the white curd and the development of "riciness". The leaves tend to become yellowish and readily fall off the stem (14).

This vegetable is difficult to hold in warm weather because of wilting and the tendency of the heads to open out. Where storage or transport is envisaged, it is an advantage to trim the surrounding leaves with long stubs as these afford a certain amount of protection (10). Hume (8) has recommended wrapping each head in glazed paper and tight packing of uniform heads in crates. For ordinary storage, dry air and free ventilation help to maintain the heads in good condition and to curtail fungal wastage (10). For New South Wales produce, Williams (18) has indicated the advantages of wrapping heads in grease-proof paper to curtail wilting and discolouration.

According to Jones *et al.* (9) the stage of development of the head markedly affects its carrying qualities. Harvesting should not be deferred too long or separation and deterioration of the curd sets in, a separated curd tending to deteriorate more rapidly than one which is compact at the time of cutting. The spreading of the head continues during storage. Various other defects, described as "riciness", "fuzziness" and discolouration are also to be avoided. The formation of proper heads, and the tendency towards premature heading have been shown by Robbins, Nightingale and Schermerhorn (15) to be directly related to nutritional conditions during growth.

In the United States of America according to Jones *et al.* (9) cauliflowers for transport are packed in single layers in crates or flats and transported in iced refrigerator cars (34°-40°F. approximately).

Platenius *et al.* (12) have described storage experiments at 32°, 40° and 50°F. At 32°F.—the temperature recommended for commercial storage—heads remained marketable for 30 and occasionally for 40 days; at 40°F. deterioration set in after 12 days, and at 50°F. heads became unsaleable after one week. Losses due to shrinkage were high, being ten per cent. after one month at 32°F. A high relative humidity during storage is therefore desirable (14). A temperature range of 35° to 39°F. has also been cited as suitable for cauliflower storage (3). For New South Wales cauliflowers Williams (18) recommends a temperature of 32°F. and R.H. of 85 per cent. Wrapped heads kept in good condition for ten weeks; unwrapped heads kept for six weeks; thereafter, having lost ten per cent. by weight, they had to be trimmed.

Scurti (16) in Turin, has indicated the possibility of preserving cauliflowers using gas storage methods, an atmosphere containing ten per cent. CO_2 and ten per cent. O_2 being effective in prolonging the storage life. Kochs (11) records the storage of cauliflowers grown in Germany and wrapped in oiled paper, over a period of six weeks at a temperature of 2°C. (35.6°F.), with R.H. of 85 per cent. using ozone as a deodoriser. Friebe Scupin (6) cites a storage period of three months at a temperature of -1°C. (30.2°F.) and R.H. of 90 per cent.

In a recent article, Wood and James (19) have called attention to the possibility of growing cauliflowers in the tropics for export, the successful cultivation of this crop having been made possible by the use of specially selected, Indian-grown strains ("Patna" and "Benares"). In 1934 (17) and again in 1936, heads of the strain, known as "Early Patna", grown in Trinidad, were held in cold storage, with air-blast refrigeration at 45°F., and in still air at 38° to 40°F. In the 1934 experiments the heads were successfully held at 45°F. for 20 days but showed rapid wilting when removed to relatively dry air at 70°F.; the 1936 trials showed that heads can easily be kept in good condition up to 40 days at 40°F., provided care is taken to avoid undue wilting.

Other Related Vegetables.

The following storage temperatures are cited for completeness. High relative humidities, of about 90 per cent., are usually desirable to avoid excessive wilting.

Broccoli	32°F. (12, 14).
Brussels Sprouts	32°-34°F. (13); 32°F. (12).

Kohlrabi	32°-33°F. (14).
Radish	31°-32°F. (14); 32°-34°F. (13); 33°-37°F. (3).
Turnip	31°-32°F. (14); 33°F. and R.H. of 85% (18); 34°-37°F. (3).
Turnip-cabbage	32°-34°F. (13).

In storage trials with several varieties of Jamaica-grown radishes, Smith (16A) observed that temperatures of 45° to 47°F. were too high, considerable wilting (with air-blast refrigeratoin) being the rule; the most suitable temperature is considered to be in the region of 34°F.

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Carrots.

Carrots are well adapted for storage, and lose little of their eating quality even after prolonged storage (10). In a recent work Platenius (9) has made the observation that, contrary to common belief, the eating quality of old carrots is equal to if not better than that of young carrots, since sweetness increases with age while the fibre content remains practically unchanged and protein hydrolysis is slow. Carrots can be held in storage for six months without serious deterioration, provided the temperature is maintained between 32° and 40°F. and the relative humidity above 90 per cent. At 50°F. breakdown begins after three months; the fibre content also tends to increase. At 30°F. carrots develop freezing injury and soon decay on being removed to higher temperatures. After five months' storage at 32° and 40°F., losses in weight of 10 and 13 per cent. respectively were recorded (9, 10). Langley, Richardson and Andes (5) have observed that the vitamins (A, B and C) do not undergo deterioration during storage.

According to Lauritzen (7) the most suitable conditions for the storage of carrots are a temperature of 0°C. (32°F.) and a relative humidity of from 90 to 95 per cent. No shrivelling was found to occur in carrots stored at 6.5°C. (43.7°F.) when the relative humidity was maintained at 90 to 95 per cent., whereas considerable shrivelling was the rule at 70 to 80 per cent.

In experiments conducted by Hasselbrink (4) carrots were kept 22 weeks at 32° to 35°F. and 39° to 40°F., losing 7 per cent. and 26 per cent. of their weights respectively. Hydrolysis of sucrose into reducing sugars was more rapid at the higher temperature. As flavour is correlated with the sucrose content the lower temperature is recommended, viz.: 32° to 35°F.; Lauritzen (6) has shown that at this temperature infection and decay, due to black rot disease, are reduced to a minimum. An Idaho report (11) states that carrots stored at 40°F. in sand or on shelves remained in good condition for upwards of five to six months. For carrots grown under New South Wales conditions and stored dry, a temperature of 33°F. and R.H. of 85 per cent. will keep this produce in good condition for two months (12). Carrots grown under moist tropical conditions must be protected against excessive wilting.

Samples of English carrots (Johnson's Intermediate variety) were taken from the clamp in December and stored at −1°, 1°, 3° and 5°C. (30.2°, 33.8°, 37.4° and 41°F.), half of each sample

being washed (1). Storage was unsatisfactory at −1° and 5°C. (30.2° and 41°F.); at −1°C. (30.2°F.) freezing occurred, while at 5°C. (41°F.) large sprouts and rootlets developed after five months' storage. At 1° and 3°C. (33.8° and 37.4°F) sprouting was inhibited, but although the washed samples remained almost free from mould on the surface for five months, considerable mould developed on the unwashed. The carrots were stored under very damp conditions; it was considered that drier conditions would probably have retarded the development of mould, though the loss in weight, which amounted to 12 per cent. in the washed sample, would then have been increased. After five months' storage the texture and flavour on cooking was moderately good.

Carbon Dioxide Treatment.

Several carbon dioxide experiments with carrots in conjunction with refrigeration have been described by Brooks *et al.* (2). In the matter of palatability, carrots subjected to CO_2 while being gradually cooled to 45° to 55°F. were as good as or better than carrots placed immediately at 32°F.; they were distinctly sweeter and better than carrots held under similar temperature conditions without carbon dioxide. These results are in agreement with those of other workers (3, 8). Exposure to carbon dioxide had a decided inhibiting effect upon *Rhizoctonia* sp. and *Sclerotinia sclerotiorum*, but little on *Bacillus carotovorus*.

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Celery.

In the tropics, celery (*Apium graveolens*) is best suited to the cooler conditions of cultivation on the hills, though good crops may also be obtained on the plains (19). In the United States of America the crop is grown in certain districts of California and Florida as well as in more northerly areas (2).

Blanching of celery may be achieved by banking up the plants with soil, by boarding-up or encircling with paper or by the use of ethylene (*see* below). According to Beattie (2) while ethylene destroys the colouring matter of the celery stalk to give a white appearance, this method of blanching does not yield the quality found in a good grade which has been blanched by treatment in the field.

Quality.

To be of good quality, celery should be white, crisp, tender, free from fibre or stringiness and of characteristic pleasing flavour; the relevant literature and problems have been considered in detail by Sayre (18). Choice of varieties and environment are important in producing high quality celery. According to Sayre, toughness and stringiness are not determined by the size or number of the vascular bundles, nor by the presence of bast fibres or a high degree of lignification in the wood vessels. The only tissue that appears to have a definite relation to stringiness is the collenchyma—a mechanical tissue situated towards the periphery of the stalk. Sayre states that it is not the amount of this tissue present which determines stringiness but the degree of hardness to which it has developed. In tough, stringy specimens the collenchyma was observed to be of particularly hard texture whereas in tender specimens, both of tender varieties and of inner stalks of tough varieties, its texture was not hardened. This is the only morphological factor which has been correlated with toughness and stringiness in celery. Over-ripeness due to delayed harvesting, is accompanied by an undesirable pithiness, loss in weight and flavour especially in early varieties (2). Pithiness, an undesirable character in celery, is correlated with a breaking down of the parenchyma cells, and with the development of large open spaces in the centre of the stalks as a result (18). Flavour is apparently more influenced by varietal than by environmental factors. The relation between cultural conditions and quality have not yet been clearly defined.

Blanching with Ethylene.

In 1925 Harvey (8) reported that small concentrations of ethylene in air (from one part per 1,000 to one part per 10,000) were effective

in hastening the blanching of celery, the so-called self-blanching varieties requiring six days and the dark green types ten to 12 days. Over-doses of the gas caused a browning of the leaves. Harvey also found that acetylene in corresponding doses was an effective blanching agent, but its use was precluded on account of its unpleasant odour. He suggests that the blanching action consists in hastening the decomposition of the green pigment, and holds the view that the quality, texture, colour and keeping quality of celery blanched by ethylene are equal to those of celery blanched in the field (9, 10). Babb (1) states that the vitamin B content of celery is not destroyed by ethylene blanching.

In ethylene blanching experiments with celery Mack (13) made the following observations: relatively low concentrations of ethylene in air (one part in 25,000 to 50,000) were considerably more effective in producing rapid and complete blanching than were relatively high concentrations (one part in 500 to 2,500); concentrations of ethylene of one part per 1,000 of air produced an injury characterised by a splitting of the stalks on the inner surface and pronounced pithiness of the stalks thus split; the acidity of the celery juice remained unchanged by ethylene treatment; the rate of respiration was more than doubled by ethylene treatment, but differences in flavour were not attributed to the accumulation of the by-products of respiration; the most rapid respiration, in stalks treated with one part of ethylene per 50,000 parts of air, was accompanied by the best blanching, but the produce obtained, though crisp and tender, was very subject to rotting; the accumulation of the carbon dioxide of respiration exercised an inhibiting action on the blanching process, so that, at high carbon-dioxide concentrations, ethylene failed to produce the usual effect. From these observations Mack has expressed the opinion that ethylene accelerates the blanching process by stimulating the activity of enzymes normally concerned with the breaking-down of various compounds in the plant. Some divergence of views as to the effectiveness of ethylene in this connection must be noted. Thus Mulder, Oelmeyer and Spencer (14) obtained no acceleration of the blanching process at concentrations of one part per 1,000 at a temperature of 25° to 26°C. and R.H. of 85 to 95 per cent. Experiments conducted at the New Jersey State Agricultural Experiment Station also yielded inclusive results (21). Hibberd (11) found that ethylene was effective in destroying the chlorophyll of celery, but does not recommend its use under Michigan conditions.

Washing and Pre-cooling.

In California and Florida special washing and pre-cooling plants are now in use (15). Using the water-immersion method, some of these can handle about 200 crates per hour. Washing is effected by placing the crated celery on a conveyor which travels slowly through a trough; during this passage—a matter of 20 feet—water is sprayed on the crates on all sides. This washing effectively cleans the product. Proceeding from the washer the crated celery is directed on to a conveyor four crates wide; the crates now travel still more slowly through a tank in an insulated room where they are immersed approximately one-half their height in water cooled to 34°F. while simultaneously the tops of the crates are saturated from above by the drip of water, slightly above freezing, from refrigerating coils lined above the tank. The entire period from the time the product is placed in the washer until it is trucked into the refrigerator car is less than 22 minutes. The celery absorbs approximately seven pounds of water per crate during the treatment which, together with the rapid cooling, is the outstanding factor in its preservation for the market. The average reduction effected in flesh temperatures is from 70° to 37°F.

Storage.

Much of the celery produced in the United States is crated and shipped for immediate consumption. In California, as described above, consignments may be pre-cooled before being placed in refrigerator cars (2).

In some early experiments on the storage of celery, Thompson (22) observed that storage in the field or in cellars is unsatisfactory because temperature and moisture conditions cannot be adequately controlled. In cold storage trials he noted that celery packed in large crates always began to decay at the centre, the amount of decay being greater than in small crates. Further detailed observations indicated that the tendency to self-heating in packs (in some instances the centre may be 3°F. higher than the margin), and uneven distribution of temperature in grid-cooled storage rooms were important factors in determining the extent of wastage. A 14-inch crate was found most suitable. At a uniform temperature of approximately 32°F. or just above the freezing point of celery, this commodity can be successfully stored for three to four months.

During storage, some growth of the centre leaves may take place at the expense of materials chiefly derived from the outer leaves (6). This increases during the first few weeks if the temperature is raised. As blanching also takes place in storage, crates intended for long storage will require less preliminary ethylene treatment.

Specially constructed chambers maintained at 33° to 34°F. (2) or 31.5° to 32°F. (17, 20) are now used for the storage of celery, whereby the commercial life may be extended by two to four months. In stacking the crates care is taken to ensure adequate ventilation (12); in some warehouses air circulating fans are installed to secure more uniform temperatures. Wilting, with concomitant loss of crispness, should be avoided by keeping the storage atmosphere at a high relative humidity, *e.g.*, 95 to 98 per cent. (17). As celery freezes at 30°F. care must also be taken that the temperature does not fall too low.

As celery is a rather perishable crop, subject to a watery soft rot at higher temperatures, only sound material should be accepted for storage. Freezing injury is marked by a general loosening of the epidermis which is evident on twisting an injured stalk. Cold storage temperatures recommended by other investigators include the following: 32° to 34°F. (4); 35.6° to 39.2°F. (5); 33° to 35°F. (7); 32°F. and R.H. of 90 per cent. (16, 24).

Carbon Dioxide Treatment.

Thornton (23) has shown that celery is susceptible to carbon dioxide injury: slight injury resulted from seven days' exposure at 0°, 4° and 10°C. to atmospheres containing 25 per cent. of carbon dioxide; still greater injury resulted from exposure to atmospheres containing 50 per cent. or more of carbon dioxide. Brooks *et al.* (3) have also described experiments in which freshly picked celery was treated to various concentrations of CO_2 during cooling to 45° to 55°F. After three days' treatment, with high initial carbon dioxide concentrations, all lots were held at 70°F. for four days. Exposure for three days to an atmosphere containing 50 per cent. carbon dioxide resulted in slight injury to the celery tops and a slight browning of the vascular tissue at the base of the stalks; a similar exposure to 20 per cent. carbon dioxide in air caused no injury to the tops and only slight traces of browning at the base. In both cases the celery stalks broke away from the stem much more readily in treated than in untreated lots. The taste of the treated celery was slightly inferior to that of untreated celery.

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(*To be continued.*)

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To be obtained from the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

BANANA DISEASES

X.—Further Observations on Cercospora Leaf Spot of Bananas.

By C. W. Wardlaw.

In view of the importance which the Cercospora leaf spot (*Sigatoka*) disease of bananas has now attained in the Caribbean region and in the Guianas, the following account of its outbreak, spread and intensification in Trinidad has been prepared.

Occurrence in Trinidad.

A collection of Giant Governor banana planting material, obtained from the Moruga district, was planted at Maqueripe Estate about January 1932. As bunches for storage experiments at the Imperial College of Tropical Agriculture were being reaped from the end of 1932 to May 1933, this plantation was frequently under observation. Cercospora leaf spotting, not hitherto recorded in the Western tropics, became well marked towards the end of 1933, though the productiveness of the Giant Governor, a plant of rank-growing habit, was not affected. Dwarf Cavendish bananas (the Trinidad Governor variety) in immediate proximity also showed leaf spotting, though in a less severe form, some time later. Early in 1934 the disease was studied in some detail by the writer and identified as being due to the fungus *Cercospora musae* Zimm., this diagnosis being verified by the authorities at the Imperial Mycological Institute. For general information a note was prepared for *Tropical Agriculture* and published in July, 1934.

Spread and Intensification.

During frequent inspections at the beginning of 1934, Cercospora leaf spot was not observed anywhere in the Maqueripe district except in this one area, the Giant Governor plot being the focus of infection. A thorough stripping and burning of all diseased leaves, undertaken as a precautionary measure, did not halt the progress of the disease and by the end of 1934 it became evident that it was spreading, adjacent Gros Michel blocks—planted in 1932-33—becoming infected. From this time onwards it became apparent that Cercospora leaf disease was generally distributed through the Island, having presumably spread from several foci of infection. At this time the Gros Michel blocks at Maqueripe, though generally infected, showed little diminution in productiveness. The general mycological observation made during 1934-35 was that the older the stand of plants, the more intensive was the infection, but at this stage premature ripening of bunches on the plant, as previously recorded by Australian workers, was not observed. During 1936 production was seriously affected. Almost without exception plants at all stages of development were severely spotted, commercial bunches being spoilt by premature ripening, a feature, as noted above, not observed in 1935. During a recent inspection (January, 1937) practically every bunch of export size showed this symptom; from several blocks scarcely a bunch was being reaped for shipment. The intensification of infection to the point where premature ripening of bunches on the plant or shortly after reaping is the rule is a further serious economic aspect of the disease. Trinidad experience indicates that it is a symptom which may not become manifest until the ordinary severe spotting of leaves has been prevalent for some time.

Physiological Observations.

On physiological grounds three aspects of the disease call for comment:

(i) From what is known of this disease it appears that leaves can only be infected when quite young, *i.e.*, at the time of unrolling or soon after. Then follows a more or less prolonged "incubation" period, so that it is only in the older leaves that the development of spots can be observed. By analogy with what is known of the manifestation of latent infections in fruits, an explanation of the long "incubation" period is that leaves, although *infected* at an early stage, only become subject to active *exploitation* by the pathogen when a certain stage in their ageing has been reached. The progressive spotting of leaves from the oldest to the youngest bears out this point of view. Stahel's* recent observations, on the other hand, might be taken as suggesting that the long incubation period is accounted for by the very slow but continuous progress of parasitic hyphae in the tissues.

(ii) Attention has frequently been directed to the fact that intensity of spotting is correlated with certain adverse growth conditions, water relations (as in water-logged clay soils, light soils subject to rapid drying out, &c.) being important. Debility and premature ageing in leaves or leaf tissues are known to be determined by unfavourable water relations. Field studies of the distribution of Cercospora spots over the leaf surface (particularly at the distal end and in proximity to the margins) would appear to indicate that in some, though not in all instances, a definite relationship of the kind suggested exists.

(iii) A recent study of bunches showing premature ripening suggests that the cumulative effect of severe leaf spotting is to create a toxic, or physiologically unbalanced condition, in the plant, so that in the apical region of the rhizome or bulb, in the true stem and finally in the bunch, definite pathological symptoms are induced. The most striking symptom is the marked pinkish colour of the pulp of prematurely ripened fingers. A less conspicuous, but easily observable symptom, is the presence of a characteristic pale bluish discolouration of some of the vascular strands of the true stem. These contain vessels in which various pathological symptoms have been or are being induced as a result of the diseased condition of the leaves. Even where the bunch is still quite

* *Tropical Agriculture*, Vol. XIV, 3, 1937.

immature, these changes can be observed by sectioning the pseudo-stem. In the later stages the presence of tyloses and vessel collapse, as already described by the writer in relation to the movement of toxic substances produced by *Bacterium solanacearum* (in Moko or Bacterial Wilt Disease) and by *Fusarium cubense* (in Panama Disease), can be demonstrated by microscopical examination.

These observations on the presence of pathological symptoms in the rhizome and true stem not only contribute towards an explanation of the premature ripening of bunches, but may have an important bearing on the progressive intensification of infections described above and on the fact that the disease may sometimes reach its greatest virulence on vigorously growing plants.

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

The Sugar Industry.

The Islands of Antigua and St. Kitts experienced more favourable weather conditions in 1936 than in the previous two years. These conditions have largely been responsible for the production of record crops estimated at 28,000 tons in Antigua and 33,000 tons in St. Kitts. The marked increase in the size of the 1937 crop over the average of recent years is also in part due to the cultivation and more suitable distribution of better varieties and to the improved cultural and manurial methods adopted as the result of the work of the Sugar Cane Investigation Committees in the respective Islands.

In St. Lucia where there is less variation from year to year in the amount of rainfall, production is gradually increasing in the main sugar cane valleys as the result of the better agricultural methods put into practice in recent years. The estimate for the 1937 crop is 9,200 tons.

In Barbados the crop is estimated at about 120,000 tons, including fancy molasses, and in Trinidad at 150,000 tons. In Jamaica the crop is expected to be 95,000 to 100,000 tons.

The sixth meeting of the Advisory Committee of the British West Indies Central Sugar Cane Breeding Station was held at the Imperial College of Tropical Agriculture, Trinidad, from 13th to 19th of January, 1937. The contributing Colonies were all represented at the meeting. The representatives were as follows:—Barbados, Mr. R. W. R. Miller, Director of Agriculture, (Chairman of the Advisory Committee); Imperial College of Tropical Agriculture, Sir Geoffrey Evans, Principal; Trinidad, The Hon. E. J. Wortley, Director of Agriculture; Jamaica, Mr. L. N. H. Larter, Geneticist, Department of Agriculture; Windward and Leeward Islands, Mr. G. A. Jones, Commissioner of Agriculture. Dr. A. E. S. McIntosh, Geneticist of the Cane Breeding Station; Mr. A. B. Killick, Assistant Director of Agriculture, Trinidad; Mr. C. C. Skeete, Assistant Commissioner of Agriculture; and Mr. P. E. Turner, Sugar Agronomist of the Trinidad Department of Agriculture also attended the meeting. Mr. E. J. Gregory, Manager of the St. Augustine Experiment Station, Trinidad, performed the duties of Secretary.

Some of the more important findings of the Committee are summarised below:—

General progress of the breeding work at the Central Sugar Cane Breeding Station.

The Advisory Committee have studied the experimental work being carried on in Barbados and are highly satisfied that progress is being made according to plan. The Committee are agreed that every possible precaution should be taken to eliminate, prior to the despatch to the Plant Quarantine Station, all those seedlings which do not exhibit a high degree of resistance to gumming disease.

Investigations into the factors influencing the ratooning of sugar cane seedlings.

The Committee are of opinion that a study of the factors governing ratooning of sugar cane varieties is of vital importance to the sugar cane industry in the British West Indies. They consider that investigations of this nature, together with intensive study as to the causes of rotting of canes, should receive the attention of the Station, and that until such time as the work on root systems, which is being conducted elsewhere shows that such studies are of practical application to sugar cane breeders, the root system investigations in Barbados should be discontinued and that work may be carried out on the above problems.

Plant Quarantine Station.

The Plant Quarantine Station Committee reported that considerable technical difficulties are being experienced in obtaining normal plant growth in the quarantine houses. It was decided to recommend that all the Departments of Agriculture of the different contributing Colonies desirous of importing sugar cane seedlings from the Plant Quarantine Station should be informed that, until further notice, after one generation in the Plant Quarantine House the seedlings would be grown for a further generation in the open in the vicinity of the Plant Quarantine House. The planting material would be under the constant inspection of the Entomologist and Mycologist attached to the Plant Quarantine Station and would thereafter be despatched direct to the respective Colonies after appropriate treatment and disinfection.

Visits of inspection by the Geneticist.

It was decided that the Geneticist and the Assistant Botanist should pay a visit of inspection to the Leeward Islands early in June and that the former should pay a similar visit to Jamaica in the autumn of this year.

Triennial Conference of the International Society of Sugar Cane Technologists, Louisiana, 1938.

The Committee consider that the Sugar Cane Breeding Station should be represented at this Conference by the Geneticist.

The Cotton Industry.

The area planted in Sea Island cotton in 1935-36 amounted to 12,386 acres being 314 less than estimated by the West Indian Sea Island Cotton Association for the season and approximately 4,320 acres more than the previous season. The increased acreage was planted chiefly in St. Vincent, Nevis and St. Kitts. Production in 1936 was more evenly distributed between the Islands. In recent years Montserrat produced approximately two-thirds of the total crop, but in 1936 mainly owing to disease resulting from unfavourable weather conditions the production in that Island fell to less than one-third of the total production. On the other hand in St. Vincent, Nevis and St. Kitts, where weather conditions were on the whole favourable, production was more than doubled.

The total production of Sea Island lint amounted to 1,477,901 lb., equivalent to 3,694 bales of 400 lb. each. This quantity was only 32 bales more than the total production of the previous year, the relatively small increase being due to the partial failure of the Montserrat crop. Production of Marie Galante lint amounted to 348,485 lb., equivalent to 871 bales of 400 lb. each, a decrease of about 15 per cent. on the crop of the previous year.

Prices during the year were on the whole better than during the previous year, being on the average 3*d*. to 6*d*. per lb. lint higher, the maximum price being about 1*s*. 10*d*. per lb. lint.

Final production figures for the year 1935-36 are set forth in Table I.

The prolonged wet season of 1936 in Antigua and the abnormally rainy January of 1937 in St. Vincent have reacted unfavourably on the 1937 crops in those Islands. The estimated production for the 1936-37 crop is set forth in Table II.

Table II.—Estimated Acreage and Production 1936-37.

Island.	Acres.	Production. Lint lb.	Bales of 400 lb.	lb. per acre.
		Sea Island.		
St. Vincent....	5,000	342,000	855	68
Barbados	191	19,100	48	100
Montserrat	5,000	1,000,000	2,500	200
Antigua	937	80,500	201	86
Nevis	3,000	290,000	725	97
St. Kitts	1,500	300,000	750	200
Anguilla	500	40,000	100	80
Tortola, B.V.I.	250	25,000	62	100
Total	16,378	2,096,600	5,241	—
		Marie Galante.		
Grenada	5,250	255,000	638	49
St. Vincent....	720	43,200	108	60
Total ...	5,970	298,200	746	—

Table I.—Production and Export Figures for Cotton in 1935-36.

Island.	Acres.	Production 1935-36. Lint. Clean (lb.)	Stained (lb.)	Total (lb.)	Bales of 400 lb.	lb. per acre.	Export 1936. Lint. Clean (lb.)	Stained (lb.)	Total (lb.)	Bales of 400 lb.
					Sea Island					
St. Vincent	3,540	357,504	39,456	396,960	992	112	360,326	35,282	395,608	989
Barbados	247	9,449	145	9,594	24	39	9,450	1,845	11,295	28
Montserrat	4,550	390,819	66,430	457,249	1,143	101	501,909	103,267	605,176	1,513
Antigua	612	113,180	4,598	117,778	295	192	113,180	4,200	117,380	293
Nevis	1,857	211,819	7,397	219,216	548	118	211,819	3,208	215,027	538
St. Kitts	1,030	212,489	22,864	235,353	588	228	237,631	25,902	263,533	659
Anguilla	400	29,234	1,237	30,471	76	76	29,234	501	29,735	74
British Virgin Islands	150	—	—	11,280	28	75	13,782	735	14,517	36
Total	12,386	1,324,494	142,127	1,477,901	3,694	—	1,477,331	174,940	1,652,271	4,130
					Marie Galante					
Grenada	5,250	—	—	280,200	700	53	—	—	280,200	700
St. Vincent	721	—	—	68,285	171	95	—	—	68,285	171
Total	5,971	—	—	348,485	871	—	—	—	348,485	871

The Citrus Weevil Investigation.

Mr. R. G. Fennah, Lecturer in Entomology, has continued the investigation of the citrus weevil problems in St. Lucia, reported in the July and October 1936 issues of this Journal.

The following notes are extracted from Mr. Fennah's third progress report on the investigation and serve briefly to indicate the progress that has been made during recent months.

In September 1936 Mr. Fennah paid a brief visit to St. Lucia to note the general situation towards the close of the annual oviposition period of the citrus weevil, and to examine such experiments as were complete at the time. A further visit in January was made with the object of making the final examination laid down in the preceding year.

The General Situation in September and January.

During the rainy season the citrus trees have made advance in growth, in spite of the fact that they have been exposed to continual attack by weevil larvae. Severe chlorosis was noticed in one or two young trees, and, on examination, they were found to have been very severely decorticated below ground. At Union Estate no further dying back of trees has taken place in the last five months (September to January), new growth has been made, and, in January, flowering was in progress and fruit was being set. On the other hand, the general appearance of the trees has not improved to any marked extent since the initial recovery at the beginning of the rains, and is still unsatisfactory. The foliage is uniformly yellowish-green; the leaves are rather hard in texture and lack the characteristic sheen on the upper surface: they are curled inwards, however, and do not drop off readily. From examination of a large number of roots it is clear that on the whole the production of fresh rootlets is carried on actively in the wet season. This holds true for all but the most severely damaged root tissue: on numerous occasions small rootlets were found springing from behind the callus formed along the edge of a recent feeding-track of *Diaprepes*. At the time of examination rain was still abundant. Providing that the trees receive a constant supply of water during the dry season it is probable that their condition will improve, since larval attack will have ceased.

In September it was found that the decrease in the number of unhatched egg-masses collected after the initial ovipositing period in July had continued, and at the end of September they were scarce. From data supplied by the Assistant Agricultural Superintendent it was calculated that less than two per cent. of the total number of egg masses laid on the trees at Union Estate were unhatched at the end of the first week in August. In January, weevil larvae taken beneath citrus had reached three-quarters of their full size, were fully grown, or were pupating. No adult beetles were seen, and no leaf damage due to their feeding was visible.

Summary of the Results of Control Tested Experimentally.

The methods so far tested are listed below, with notes on their performance.

Lead arsenate used as a repellant spray: significantly depressing effect on oviposition, but not complete enough to warrant large scale use.

Lead arsenate applied to the soil round the base of tree. Significantly depressing effect on subterranean infestation. Not harmful to the trees during the experimental period.

Soil fumigants.

Carbon bisuplhide applied as emulsion to soil round base of tree: not significantly effective. Not harmful to the trees in dosage applied.

Hydrocyanic acid gas (Cyanogas; potassium cyanide, &c.). On available evidence not effective in the plantation. Capable of causing high mortality when used under controlled conditions. Not harmful to trees as applied.

Paradichlorbenzene. } Not significantly effective in the one experiment set up. Not harmful to the trees as applied.
Vaporite. }

Protective layers.

Paper with asphaltic oil: not effective. Paper treated with "Solignum": not effective.

Molasses and mercuric chloride on soil: not effective.

Molasses and mercuric chloride on bagasse: significantly protective.

Asphaltic oil on bagasse: significantly protective.

Some Considerations for Future Experimentation.

The chief desideratum would logically appear to be the laying down of a large scale experiment, on uniform material, to test the effects of the lead arsenate and of the oiled-bagasse treatment against a control over several seasons as regards growth and yield of the trees and quality of fruit. The bagasse treatment should be examined for durability and its exact cost determined. It should be one inch thick, not half an inch, as laid down in 1936, and should be repaired when, by mischance, a portion of the surface is disturbed before the whole has settled down. Secondly, on trees severely checked by weevil attack the effects of inarching would be worth experimental examination, to see whether, by this method, an unthrifty tree might be restored to full vigour when the additional stock is protected.

In the nursery the effectiveness and cost of hand-picking should be determined, and, if generally effective, the fumigation of roots leaving the nursery should be reduced to a standardized technique.

Arrangements for carrying on the Citrus Weevil Investigation.

Arrangements are being made for Mr. Fennah to be seconded from the Imperial College of Tropical Agriculture to undertake the duties of Entomologist for the present weevil investigation.

THE CACAO INDUSTRY OF TRINIDAD.—*Continued.*

SOME ECONOMIC ASPECTS.

Series II.—A financial survey of estates during the seven years 1923-4 to 1929-30.

By C. Y. Shephard.

PART V.—COMPARISON OF VARIOUS GROUPS OF ESTATES.

SECTION (*c*).—COMPARISON OF ESTATES GROUPED ACCORDING TO EXPENDITURE PER ACRE ON CULTIVATION (*See* Table VIII and Figs. XXXII-XXXVII).

Cultivation and Yields (*See* Figs. XXXIV and XXXV).

Previous analyses suggested the absence of any relationship between differences in the expenditure on cultivation and differences in yields on various groups of estates. This impression is strengthened by a comparison of estates grouped according to their expenditure per acre on cultivation. It is true that the group with the highest expenditure per acre, $15.44 (£3 4*s.* 4*d.*), obtains the highest yields of cacao, 343 lb. per acre (6.94 bags per 1,000 pickets), but the group spending least on cultivation, $4.84 (£1 0*s.* 2*d.*) per acre, obtains exactly the same yield, namely 236 lb. per acre, as the group which spends $11.30 (£2 7*s.* 1*d.*) per acre. Moreover, the group spending $7.42 (£1 10*s.* 11*d.*) per acre on cultivation obtains much higher yields, 289 lb. per acre, than the group spending $11.30 (£2 7*s.* 1*d.*), which obtains only 236 lb. per acre.

Expenditure on Cultivation (*See* Fig. XXXIV).

The increased expenditure per acre on cultivation from class to class is spread over most of the individual items. The only exceptions are found in the most intensively cultivated group, which spends a little less than the preceding group in trimming and pruning, cutlassing and weeding, and miscellaneous cultivation. An interesting feature is the exceptionally high expenditure of $3.43 (14*s.* 3½*d.*) per acre on 'applying manure' by the most highly cultivated group, compared with 97 cents (4*s.* 0½*d.*), 33 cents (1*s.* 4½*d.*) and nine cents (4½*d.*) in the preceding groups. Most of this expenditure was incurred in digging trenches in the cacao fields and filling them with vegetable refuse. The fact that the most intensively cultivated group consists of estates much below the average in size supports similar evidence given in Section (*b*).

Total Expenditure (*See* Fig. XXXII).

The total expenditure per acre rises with the expenditure on cultivation. Thus, the group spending most on cultivation has a total outlay nearly two and a half times as great as the group spending least on cultivation. The additional expenditure is spread over the majority of the items. The cost of management and supervision is unusually high in the most intensively cultivated group, amounting to $8.74 (£1 16*s.* 5*d.*) per acre, while the expenditure on stock, buildings, and estate supplies is also much above the average. The small size of these estates accounts, in large measure, for the heavy incidence of these items.

Cost of Production and Profits (*See* Figs. XXXIII XXXVI and XXXVII).

There is a marked difference between the costs of production of the two lower and the two higher spending classes. Thus, those estates spending least on cultivation produce cacao at a cost of $10.89 (£2 5*s.* 4½*d.*) per bag, and the next class produces at $12.28 (£2 11*s.* 2*d.*) per bag, but in the third class the cost jumps to $17.94 (£3 14*s.* 9*d.*) per bag, and rises slightly to $18.18 (£3 15*s.* 9*d.*) in the fourth class. The lower spending classes show profits of $7.40 (£1 10*s.* 10*d.*) and $6.18 (£1 5*s.* 9*d.*) per bag, contrasted with 94 cents (3*s.* 11*d.*) and 55 cents (2*s.* 3½*d.*) in the higher spending classes. The profits per acre show a sharp contrast between the low and high spending classes of estates. Those estates spending least on cultivation obtained a profit of $10.60 (£2 4*s.* 2*d.*) per acre, and the next class slightly more, namely $10.80 (£2 5*s.* 0*d.*), per acre. The most intensively cultivated estates, however, show a profit of only $1.15 (4*s.* 9½*d.*) per acre, and even in the preceding class the profit is only $1.35 (5*s.* 7½*d.*) per acre. Hence, those estates which spend much above the average on cultivation and other items obtain the lowest profits.

Subsidiary Crops (Items 23, 32 and 33, Table VIII).

Estates spending more than others on cacao also spend more on subsidiary crops. The percentages of the total expenditure devoted to crops other than cacao average five per cent. on estates spending least on cacao cultivation, eight per cent. in the second class, 19 per cent. in the third class, and 24 per cent. on the most intensively cultivated estates. The revenue from subsidiary crops rises in the same order, and amounts to 3, 5, 18 and 47 per cent. respectively, of the total revenue. Thus, the most intensively cultivated estates derive nearly half their revenue from sources other than cacao. These estates are very heavily mortgaged, and pay $11.56 (£2 8*s.* 2*d.*) per acre of cacao in interest charges, but it will be noted that subsidiary crops are more capable than cacao of bearing this burden. The second most intensively cultivated cacao estates pay only 35 cents (1*s.* 5½*d.*) in interest charges.

Summary.

The differences in amounts spent on cultivation by various groups of estates are not accompanied by similar differences in yield. Those estates spending least on cultivation obtain the same yields as those spending two and a half times as much. Each increase in expenditure on cultivation is accompanied by increases in total expenditure, costs of production per bag of cacao, and expenditure on and revenue from subsidiary crops. The two low spending groups obtain practically the same high profits per acre, while the two high spending groups obtain much the same low profits. The most intensively cultivated estates are most heavily mortgaged, but the preceding class is least encumbered.

Table VIII.—Analysis of the Expenditure, Revenue, &c., of 126 Trinidad Cacao Estates grouped according to **EXPENDITURE PER ACRE ON CACAO CULTIVATION** for the seven financial years 1923-4 to 1929-30.

No.	Item. Description.	Expenditure per Acre of Cacao. Exp. of Group on Cultivation. Under $6.00.	$8.00	$12.00	$14.00 or more.	Cost per Bag (165 lb.) of Cacao. Exp. of Group on Cultivation. Under $6.00	$8.00	$12.00	$14.00 or more.	Item No.
		$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	
1	Management and Supervision	4.43	5.04	5.40	8.74	3.09	2.88	3.77	4.20	1
	Cultivation :									
2	"Supplying" Cacao Trees	.41	.74	1.05	1.85	.29	.42	.73	.89	2
3	Trimming and Pruning Trees	1.29	2.08	2.38	2.29	.90	1.19	1.66	1.10	3
4	Cutlassing and Weeding ..	2.13	3.15	4.62	4.04	1.49	1.80	3.23	1.94	4
5	Draining and Roundridging	.63	.80	1.75	2.75	.44	.46	1 22	1.32	5
6	Applying Manure ..	.09	.33	.97	3.43	.06	.19	.68	1.65	6
7	Pests and Diseases ..	.17	.20	.27	.88	.12	.12	.19	.42	7
8	Miscellaneous Cultivation ..	.12	.12	.26	.20	.08	.07	.18	.09	8
9	Total Cultivation ..	4.84	7.42	11.30	15.44	3.38	4.25	7.89	7.41	9
10	Reaping	2.23	2.77	2.43	3.53	1.56	1.59	1.70	1.70	10
11	Manufacture	.77	.96	.80	1.14	.54	.55	.56	.55	11
12	Live Stock	.84	1.28	1.11	1.85	.59	.73	.77	.89	12
13	Buildings	.68	1.04	1.11	2.88	.47	.59	.77	1.38	13
14	Taxes	.57	.65	.61	1.33	.40	.37	.43	.64	14
	Estate Supplies :									
15	Manures ..	.02	.01	.34	.04	.02	.01	.24	.02	15
16	Feed	.32	.48	.53	1.17	.22	.27	.37	.56	16
17	Other	.43	.94	1.08	1.66	.30	.54	.75	.80	17
18	Total Supplies ..	.77	1.43	1.95	2.87	.54	.82	1.36	1.38	18
19	Miscellaneous	.22	.18	.45	.63	.15	.10	.32	.30	19
20	Roads and Bridges ..	.30	.39	.44	.98	.21	.22	.30	.47	20
22	Total Cost	15.65	21.16	25.60	39.39	10.93	12.10	17.87	18.92	22
23	Revenue from Inter-cultivated crops ..	.54	.36	.36	1.86	.38	.21	.25	.89	23
24	Cost on Estate	15.11	20.80	25.24	37.53	10.55	11.89	17.62	18.03	24
25	Transport to Merchant's Store	.49	.68	.46	.30	.34	.39	.32	.15	25
26	Cost at Merchant's Store ..	15.60	21.48	25.70	37.83	10.89	12.28	17.94	18.18	26
29	Revenue from Cacao ..	26.20	32.28	27.05	38.98	18.29	18.46	18.88	18.73	29
30	Profit on Cacao	10.60	10.80	1.35	1.15	7.40	6.18	.94	.55	30
31	Loss on Cacao	..	..	..	..	..	..	..	..	31
32	Other Expenditure ..	.75	1.79	6.11	11.64	.53	1.02	4.26	5.59	32
33	Other Revenue	1.14	2.88	6.13	34.30	.80	1.64	4.28	16.48	33
34	Total Expenditure ..	16.35	23.27	31.81	49.47	11.42	13.30	22.20	23.77	34
35	Total Revenue	27.34	35.16	33.18	73.28	19.09	20.10	23.16	35.21	35
36	Profit	10.99	11.89	1.37	23.81	7.67	6.80	.96	11.44	36
37	Loss	..	..	..	..	..	..	..	..	37
38	Interest Received	.01	.03	.02	..	.01	.02	.01	..	38
39	Interest paid	1.99	2.55	.35	11.55	1.39	1.46	.24	5.55	39
40	Net Profit	9.01	9.37	1.04	12.26	6.29	5.36	.73	5.89	40
41	Net loss	..	..	..	..	..	..	..	..	41
		Total.				Average.				
42	Cacao Acreage	11,739	14,408	5,827	246	280	232	307	82	42
43	No. of Cacao Pickets in 1000's	3,116	4,033	1,721	74	74	65	90	25	43
44	Valuation in 1000's $ ..	2,547	3,784	1,206	129	61	61	63	43	44
45	Yield in bags of Cacao ..	16,809	25,202	8,346	512	400	406	439	171	45
46	Yield in bags per 1000 pickets	..	..	..	..	5.39	6.25	4.85	6.94	46
47	Yield in lb. per acre ..	..	..	..	..	236	289	236	343	47
48	Yield in lb. per picket ..	..	..	..	..	.89	1.03	.80	1.14	48
49	Price of cacao per fanega in $	..	..	..	..	12.20	12.30	12.59	12.49	49
50	Per cent. return on capital ..	..	..	..	..	5.07	4.53	.66	4.53	50
51	No. of estates surveyed ..	42	62	19	3	..	..	..	..	51

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO EXPENDITURE PER ACRE ON CULTIVATION, 1923-4 TO 1929-30

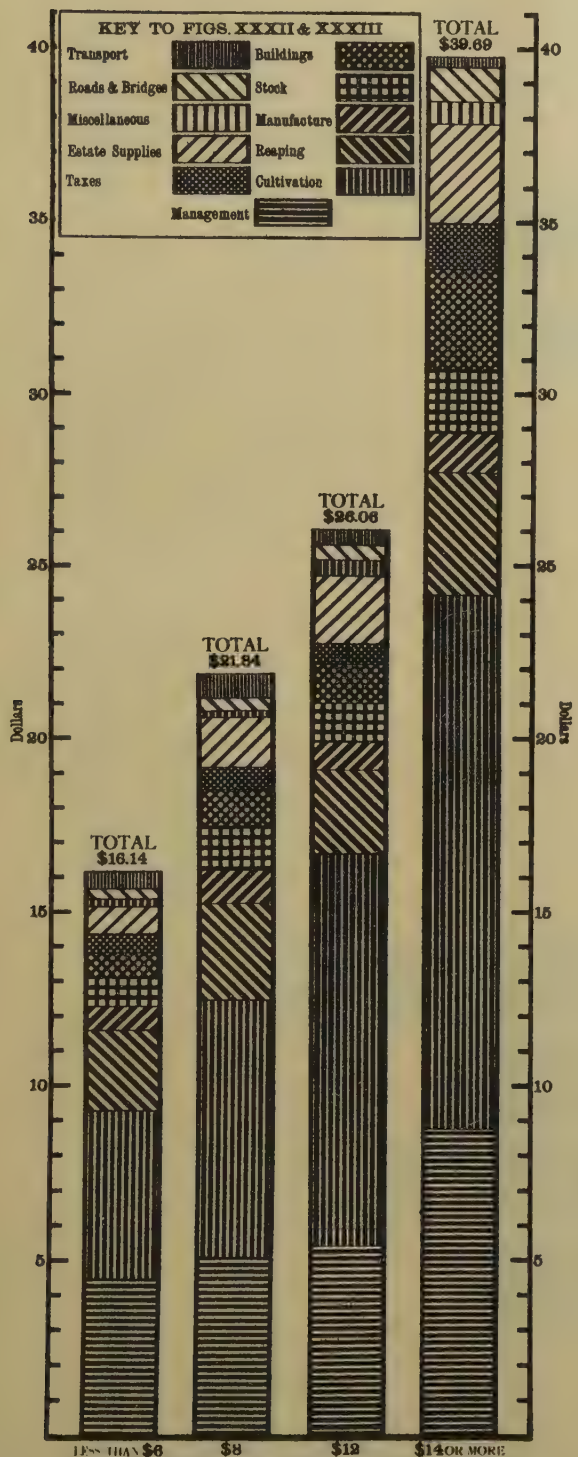

FIG. XXXII AVERAGE ANNUAL EXPENDITURE PER ACRE

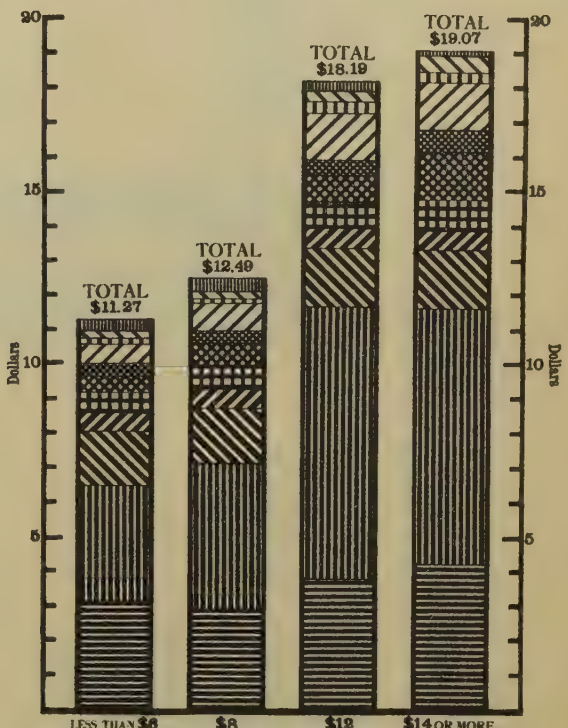

FIG. XXXIII. COST OF PRODUCTION PER BAG (165 lb.) OF CACAO

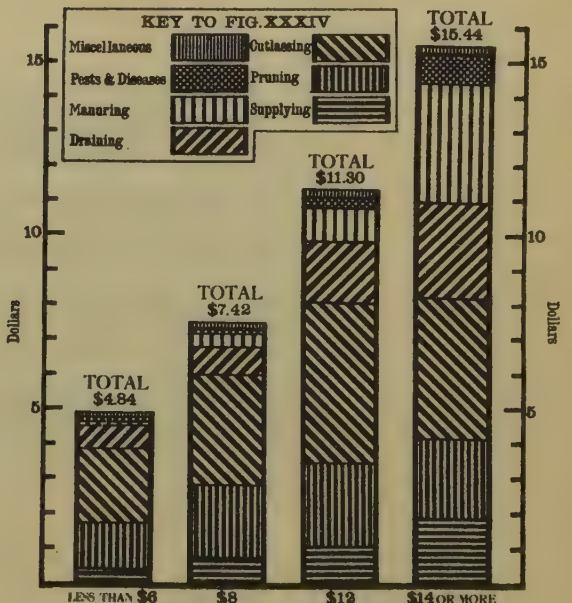

FIG. XXXIV. AVERAGE ANNUAL EXPENDITURE PER ACRE ON CULTIVATION

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO EXPENDITURE PER ACRE ON CULTIVATION, 1923-4 TO 1929-30

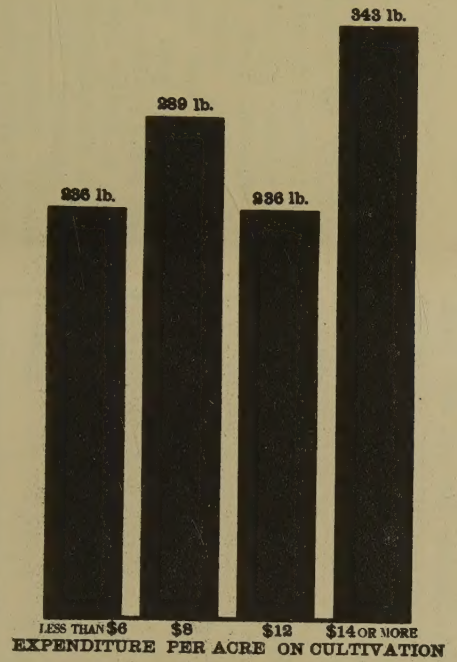

FIG. XXXV. AVERAGE ANNUAL YIELD PER ACRE

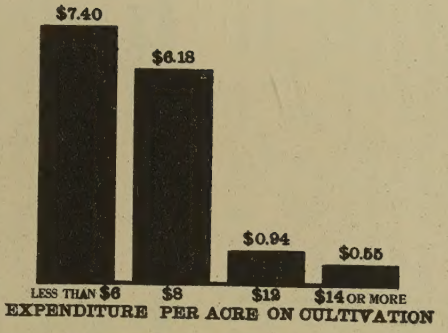

FIG. XXXVI. PROFIT PER BAG (165 lb.) OF CACAO

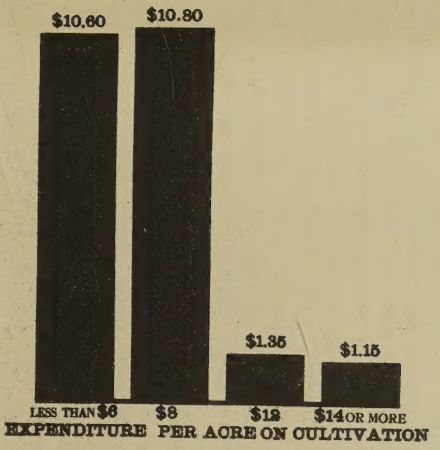

FIG. XXXVII. AVERAGE ANNUAL PROFIT PER ACRE

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Rôle of Silicon in the Plant.

A series of papers upon this subject by A. Sreenivasan has recently appeared (*Proc. Indian Acad. Sci.*, 1, 2 and 3). The inquiry appears to have arisen out of the fact that the rice plant, which accumulates exceptionally large quantities of silicon in its ash, grows so satisfactorily under swamp conditions. This raised the question whether swamp conditions are particularly favourable for silicate supply and also raised anew the question as to the rôle of silicon in the plant. An extensive series of experiments with rice, grown both in swamp and dry soil conditions, showed that whilst both phosphate and silicate manurial treatments increase yield, silicate is particularly useful in raising the yield from manured arid soils to practically the same level as that in swamp soils. The conclusion is reached that the swamp conditions, therefore, are suited to the rice plants because thus large amounts of silica are supplied to the plant which would otherwise remain unavailable. The rôle of silicon still remains obscure ; the author points out that its accumulation may be a secondary result of growth in swamp conditions which are otherwise favourable to the plant, for example, on account of the resultant presentation of nitrogen to the root system in ammoniacal form. The mode of entry of silicon into the plant also remains obscure but this detailed examination has cleared up many points as to the behaviour of silicates in the soil, to which they contribute both an alkali and a silicate gel, and as to their significance in the manurial treatment of the rice crop.— (*Nature*, Vol. CXXXVIII No. 3499, p. 889, 1936.)

* * *

Evaluating Irrigation Waters.

Valuable data relative to the evaluation of irrigation waters are published by Gy. Várallyay and E. Fejér. Several samples of various heavy soils were irrigated in laboratory experiments. After evaporation of the used amounts of irrigation water, the pH values, exchangeable bases, mechanical composition, and contents of total salts and soda of the treated soils were determined. As this method requires much time for the evaluation of irrigation waters, a quick method, consisting of the determination of dry matter content, alkalinity, total hardness, and soda content of the water is proposed. Waters can be used for irrigation, according to the authors, if their content of dry matter remains below 500 mg. per litre, and provided they contain no soda. They cannot be recommended for irrigation when they contain more than 500 mg. of dry matter, or more than 100 mg. of soda per litre. These values will simplify the evaluation of waters for irrigation in Hungary.—(*Ind. & Eng. Chem. News Ed.* Vol. XIV, No. 22. p. 450, 1936.)

Are Sour Oranges due to Lack of Phosphorus ?

The acidity of Valencia oranges was increased by the application of potassium sulphate (25 lb. per tree) but was decreased by applications of either superphosphate or bone meal (40 lb. per tree). Phosphate fertilizers also increased the juice content of the fruit. Fertilizers had relatively little effect on the total solids in the fruit, changes in the solids to acid ratio being due chiefly to changes in the amount of acid. The effect of the fertilisers, particularly bone meal, was greater when they were applied in trenches dug around the trees to a depth of nine inches, and then forked into the root zone, than when they were applied broadcast on the surface of the soil about the trees and then forked in. Phosphate fertilizers increased the phosphate content of the juice from 0.027 to 0.030 to 0.038 per cent. but had no effect on the potassium content. Potassium sulphate increased the potassium content of the juice from 0.20 to 0.21 to 0.24 to 0.25 per cent., but had no effect on the phosphate content. South African Valencia oranges contain only about half as much phosphate as those grown in California.— (J. E. van der Plank and F. A. S. Turner in *Farming S. Africa*, 11, 59-60 (1936) ; Abstr. in *Chem. Abstr.*, Vol. XXX, No. 18, 1936, p. 6492.)

* * *

Infertility of Subsoil Caused by Phosphate Deficiency.

Experiments designed to identify the cause of infertility of the subsoil a tthe Sugar Cane Experiment Station in Mauritius are described in the Sixth Annual Report for 1935 of the Sugar Cane Research Station of Mauritius. Boxes were filled with top soil, subsoil and a mixture of the two in the proportion of four to one. Pen manure and phosphate were added singly and together, and maize plants were grown in the different soil cultures. The following yield results were obtained :—

	Yield of Dry Matter (grammes).			
	No Treatment.	Phosphate.	Pen manure.	Phosphate and Pen manure.
Top soil	107.2	—	—	—
Mixture (4 : 1)	92.4	144.8	131.6	150.1
Subsoil	5.5	103.8	100.2	157.6

These data show that the infertility of the subsoil is mainly caused by a lack of phosphate, since the addition of phosphate or of pen manure increases the yield of the subsoil to that of the top soil. When both manures were added together, the yield was still further increased. The experiment is to be repeated in the field with sugarcane as the test plant.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.) :—

	Foreign. s.	d.	*Preferential.* s.	d.
28th January	6	3	9	11¼
4th February	6	0	9	8¼
11th February	6	0¾	9	9
18th February	6	1½	9	10½
25th February	6	4½	10	0
4th March	6	6	10	2¼
11th March	6	9¾	10	6
18th March	6	9	10	5¼
(*19th March*, 1936)	4	9	8	6¾

The market has continued very steady and although prices of raws have moved within narrow limits they have showed on balance an improvement of about 3*d*. per cwt. More recently the market has experienced renewed firmness and activity, and prices have risen further. The announcement that a Sugar Conference will be held in London has created a good impression and is partly responsible for the firmer undertone. In regard to British Colonial Sugars attention is drawn by Messrs. C. Czarnikow to the conditions under which the special "quota" subsidy of 3*s*. per cwt. was granted in 1934. If the average price of sugar in the second half of any calendar exceeds 7*s*. per cwt. c.i.f. this special preference will be reduced by 9*d*. per cwt. for every 6*d*. per cwt. in excess of 7*s*., so that if the world price rises to 9*s*. c.i.f. the whole of the additional 3*s*. per cwt. preference will be automatically extinguished.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :

	American Mid.	*Egyptian F.G.F. Sakel.*
29th January	7.34	10.25
5th February	7.30	9.96
12th February	7.28	9.85
19th February	7.22	9.97
26th February	7.41	10.21
5th March	7.70	—
12th March	7.94	—
19th March	7.88	—
(*20th March*, 1936)	6.34	9.31

Prices for American still tend to rise. Owing to absence of supplies no business has been reported in West Indian Sea Island.

* * *

COPRA.—With an absence of trade demand prices have shown a gradual decline and the nominal value for West Indian f.m.s. is £4 15*s*. 0*d*. lower at £20 per ton c.i.f.

COCOA.—Since last writing the market generally has been rather quiet, pursuing an irregular and somewhat indecisive mood. Fluctuations on the terminal markets remain in the minds of buyers of actuals and consequently they are slow to make up their minds. The market seems to be lacking confidence a little, and one has still to see the effect of liquidation of terminal positions as they come round. Accra has been quoted at 51*s*. c.i.f. and locally $15.25 per fanega is freely paid to day for Plantation Cocoa.—*By Courtesy of the Cocoa Planters' Association of Trinidad*).

* * *

RUBBER.—Quotations for plantation sheet have ranged as follows :—

	Pence per lb.
28th January	10 3-4
4th February	10 7-16
11th February	10 1-2
18th February	10 3-8
25th February	10 13-16
4th March	10 13-16
11th March	11 9-16
18th March	12 9-16
(*18th March*, 1936)	7 1-2

The market has been subject to fluctuations due to uncertainty caused by strikes in America but the undertone has on the whole remained steady. According to the *American Questionnaire* consumption for January is given at 48,743 tons which is higher than it was in the same month last year. The fall in stocks is said to be due to a persistent steady demand for near rubber from manufacturers.

* * *

COFFEE.—The Brazilian market has been very strong but has lost ground owing to speculation in Santos. Costa Rica :—Up to 112*s*. per cwt. for Country cleaned and to 124*s*. for London cleaned. Kenya :—Bold sizes selling between 60*s*. to 70*s*.

* * *

BANANAS.—According to the *West India Committee Circular* for 25th February there has been no improvement in demand and Jamaicas continue unchanged at £17 5*s*. 0*d*. per ton delivered London and £17 nearest station Province. Brazilians are also unchanged at £14 delivered London and £15 Provinces.

* * *

LIME PRODUCTS.—*Lime Oil.*—Sales of Hand-pressed have been made at 32*s*. 6*d*. per lb. Sellers of Distilled continue to ask 22*s*. 6*d*. per lb. *Lime Juice.*—There is no demand for Concentrated and Raw is quiet with the quotation nominal.—(*West India Committee Circular* 25th February, 1937.)